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THE METEOROLOGICAL HISTORY OF THE NEW ENGLAND HURRICANE OF SEPT. 21, 1938

By CHARLES H. PIERCE

[Weather Bureau, Washington, D. C., July 1939.]

A general account of the damaging hurricane that swept northward through New England on September 21, 1938, was given by Ivan R. Tannehill in the September 1938, issue of the MONTHLY WEATHER REVIEW. The purpose of the present discussion is to investigate the details of the structure and the motion of the storm as shown from surface and upper-air observations within or near it; in these respects the cyclone was exceptional owing to its passage into a region where frequent observations from a relatively dense network of reporting stations could be obtained and where a certain amount of aerological material was available. This made it possible to study in greater detail than has been possible in previous hurricanes such matters as the action with extra-tropical fronts, the winds and temperatures aloft in the vicinity of the storm and the details of a peculiar secondary cyclonic area near the low center. Much of the information appears useful in developing the theory and actual descriptive knowledge of tropical cyclones in general. The series of detailed maps of the storm is reproduced here in full because it is believed that such a complete series is unique in hurricane studies, and because the charts tell much that has been left unsaid in the text.

This storm has been ranked as "America's costliest disaster." The exact property damage cannot, of course, be ascertained; but according to the Travelers Insurance Co. of Hartford, Conn., the surveys by the insurance trade and others justify the acceptance of an estimate of at least $400,000,000, as compared with the commonly accepted figures of $350,000,000 loss in the San Francisco earthquake and fire of 1906 and $200,000,000 in the Chicago fire in 1871. The hurricane at Galveston, Tex., in 1900 took 6,000 lives, as against only 680 in the 1938 storm; but the property damage in the former was but $30,000,000. About 95 percent of the hurricane damage in New England was not covered by insurance.

The actual history of the hurricane goes back to some time before September 13, when it was noticeable in the region of the Cape Verde Islands. However, it was not until September 16 that the meteorological conditions began to operate in the western Atlantic and eastern United States that determined the peculiar destiny of the storm from that date through the 22d. Therefore, the present discussion will start with conditions that existed on September 16 and extended through the 22d. An outline of the circulation aloft, especially on isentropic surfaces, will first be given.

On September 16, the hurricane was located approximately at latitude 23° N. and longitude 53° W. In referring to figures 1a and 1b, which show the winds at 10,000 and 6,000 feet on this date, it will be noted that there was a very strong anticyclonic circulation the axis of which extended east and west at about 25° N., with the western tip over Florida. The isentropic chart, figure 1c, shows that a moist tongue was streaming around the western periphery of this strong anticyclone. All of the aerological stations on the eastern seaboard showed high moisture content, while the air west of the Appalachians was dry. During the 16th and on the 17th, a warm anticyclone was developing over the northeastern part of the country. This is shown in the upper air circulation at 6,000 feet at 4 a. m. on September 17 (fig. 2b). At the same time the axis of the strong southern high was shifting northward, as is indicated by Bermuda's winds on the 6,000 and 10,000-foot upper-air maps (figs. 2a and 2b) for September 17. The isentropic chart of September 17 (fig. 2c) shows that there is a branch of the moist tongue making its way north-northeast up the North Atlantic coast. It was this branch that became the main moist tongue and that caused the heavy rainfall in New England during the next 5 days. The synoptic chart (fig. 8) for September 17, 7:30 a. m., shows a wave development over southeastern Virginia. This and several other waves along the front brought the warm air at the ground farther and farther to the northeast.

By the 18th (Fig. 3a), the warm anticyclone became well established north of Bermuda, with a ridge extending south-southwestward along the coast. Over New England, the winds aloft which had been from west-southwest on the 16th, now became south-southwest. Although we have no upper-air data from Bermuda, the surface wind which was southwest on the 16th shifted to east by the 18th.

While these changes were taking place, a deep LOW at the surface and aloft was developing just west of Chicago which accentuated this strong south-southwest flow. This LOW shows up on the 10,000-foot map at Chicago, which had a pressure fall of 0.2 inch in 24 hours. The LOW at the surface occluded and filled over Michigan on September 18, but the cold air imported during the occlusion maintained a deep LOW aloft. Thus between the cold LOW centered in the vicinity of Michigan and the warm anticyclone centered north of Bermuda, the conditions were ideal for a rapid transportation of warm moist air from the south along the east coast.

On figure 3a, showing the upper-air circulation in the Tropics on the 18th, it will be noted that, as the hurricane approached the West Indies, the winds became strong northeast. In connection with this, on the isentropic chart (fig. 3c) there was a marked dry tongue drawn in from northern latitudes which appeared very distinctly over St. Thomas.

On September 19 the hurricane was located at 24° N. and 70° W. The upper-air winds indicate a pronounced trough in this region (fig. 4a). With the shift of wind into

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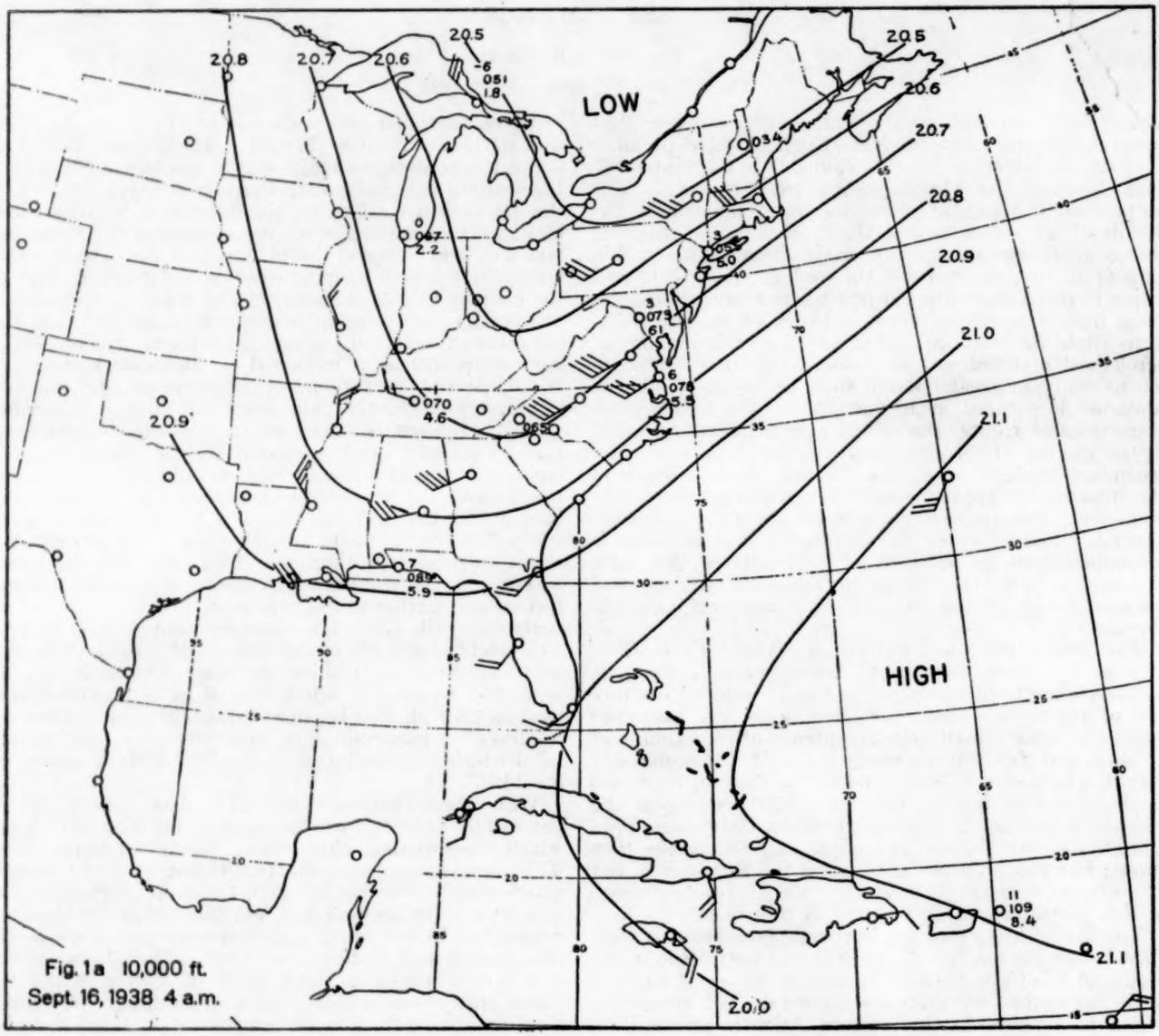
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Fig. 1a 10,000 ft.
Sept. 16, 1938 4 a.m.

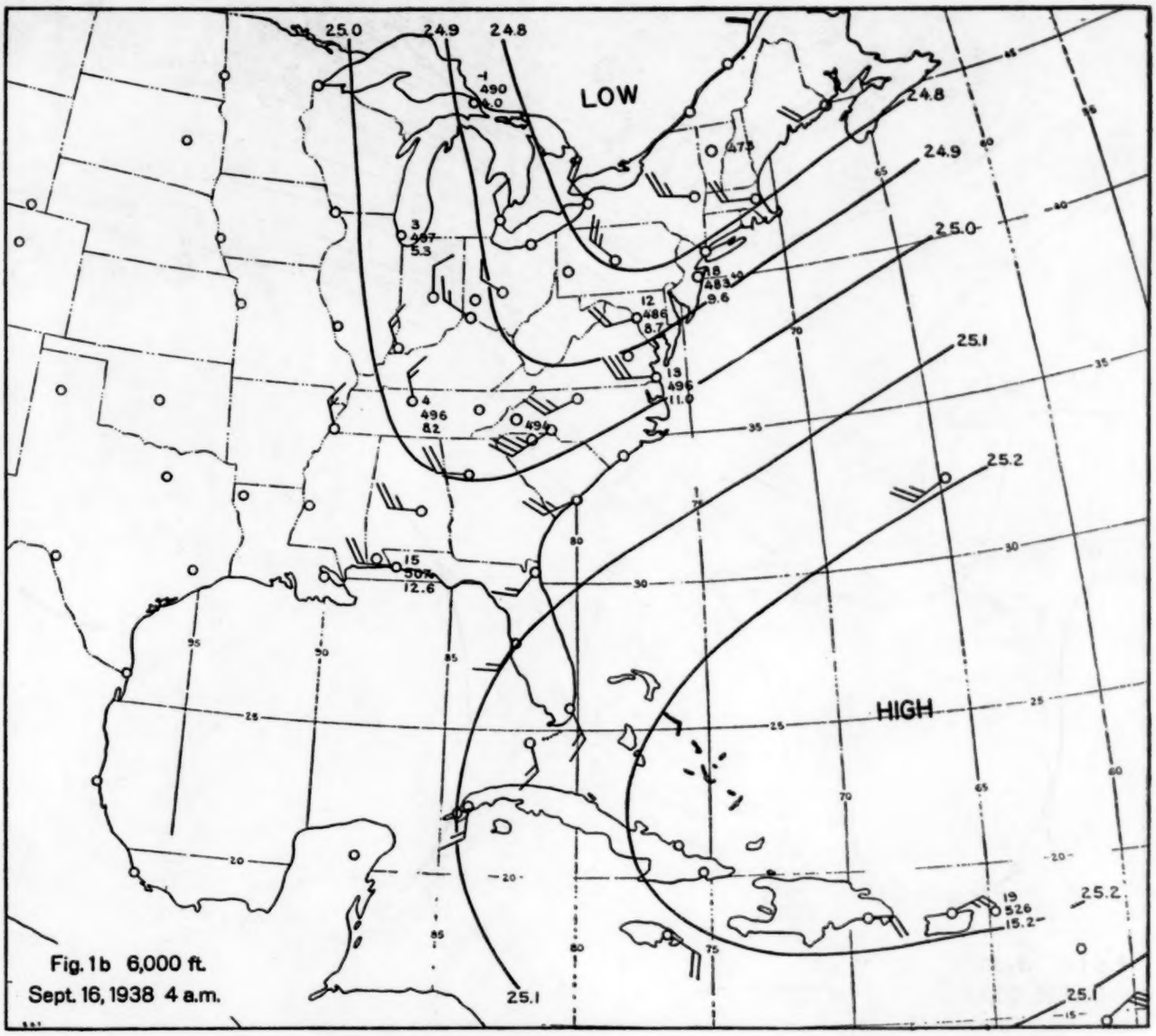
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Fig. 1b 6,000 ft.
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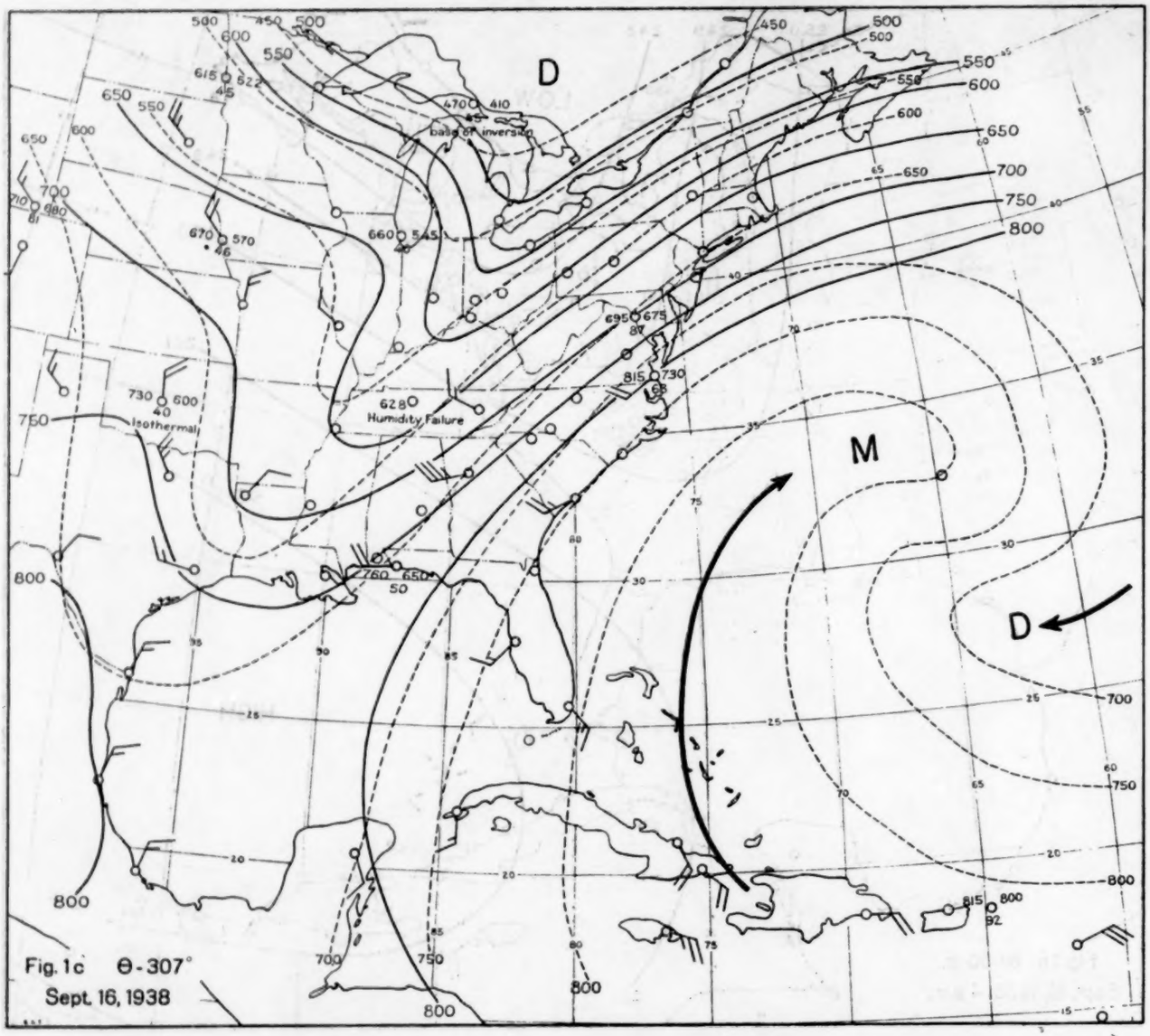
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Fig. 1c Θ-307°
Sept. 16, 1938

the southeast at St. Thomas, a considerable increase in moisture was noted at this station. This was produced by the moist, more unstable air drawn in by the hurricane from the doldrum regions. (See fig. 4c).

CONDITIONS IN THE EASTERN UNITED STATES

Over the eastern part of the United States, cold air was being imported from the northwest at Chicago and Nashville and warming was continuing along the eastern coast. This produced an even stronger pressure gradient than was found on the 18th. Winds in the upper air were all force 6 and 7 from the south-southwest.

The steep temperature gradient is also shown on the isentropic chart for the 19th (fig. 4c). It will be noted that the slope of the surface is relatively flat in the extreme east, but becomes very steep westward from Ohio. This agrees with the position of the eastward-moving cold front associated with the stationary LOW over Michigan. With the cold air so deep, the cold front was naturally quite steep. It is the author's belief that this cold front had much to do with maintaining the energy of the hurricane after the morning of the 21st.

As the secondary cold front moved eastward, steepening of the isentropic slopes along the coast resulted. This caused rapid lifting of the moist air to the condensation level, to produce heavy rainfall, especially over New England, on the 20th. On the isentropic chart (fig. 5c) it is noted that the 307° surface has a very steep slope, with the moist tongue, with strong south-southwest winds still maintained across New England, extending from the Tropics. However, dry air from the northwest was flowing into the southeastern section of the country. On this date, the hurricane, still surrounded entirely by tropical Atlantic air, was located at 27° N. and 75° W. That the circulation of the hurricane was maintained aloft is shown on figure 5a by the north-northwest wind at Miami and the south wind at Charleston.

In the northeast the cold air seemed to be definitely pushing eastward now. In fact, Mount Washington, which had been in the tropical air for several days, was now in the polar air. The front separating tropical air from polar air was also followed by the steep secondary front from the west, which should have given it added momentum. If this were true, the frontal trough should have been out over the ocean by the 21st, and the hurricane would have moved to the northeast along this trough. The apparent eastward push of the cold air did not last, so that by 7:30 p. m. of the 20th the tropical air had pushed westward again in New England; Mount Washington observed a south wind force 4 Beaufort and a temperature of 54. (Compare Mount Washington on figures 9 and 10.) C. F. Brooks at Blue Hill Observatory also noted that the movement of the upper clouds on the 21st was from the south. Farther south, however, the cold air continued to push eastward. This is indicated by the autographic records at Hatteras, which showed a wind shift from southwest to northwest and a sudden drop in temperature. Within the circulation aloft, as is shown on the 6,000-foot upper-air chart of 4 p. m. (fig. 5b), there seems to be a trough forming between the cold LOW near Cleveland and the LOW formed by the hurricane. However, two separate centers are still maintained.

The situation at this point may be stated briefly as follows: The subtropic anticyclone is displaced quite far to the north with a quasi-stationary front running from Maine south-southwest to Virginia. To the east of this front is very warm moist air and to the west there has been an importation of a deep cold-air mass. The hurricane which was previously surrounded entirely by tropical maritime air is now approaching a region where there are two distinct air masses.

FRONTS IN THE HURRICANE

During the night of the 20th, the hurricane passed through a transitory stage. It changed from a tropical to an extra-tropical storm—an extra-tropical storm, however, that maintained hurricane intensity.

Like most other extra-tropical storms, this one had a definite system of fronts. On the face of it, this sounds like an absurd statement, because meteorologists think of a deep circular LOW as one that contains no fronts. There may be those that have occluded and "wound up" their fronts and therefore are entirely surrounded by polar air, or there may be hurricanes that are surrounded by tropical air. However, when the hurricane moves into a region where there is a definite front with cold dense air to the west or north, then the tropical air of the hurricane is going to ride up over the dome of cold air to the north of the LOW center, and the circulation will cause the cold air to blow in from the west in the southern part of the LOW. Now, if the hurricane continued to move slowly, then the cold air would soon sweep around the center and occlude the tropical air. This would result probably in the filling of the hurricane. In the case of September 21, however, it must be remembered that the acceleration of the storm was extremely rapid, so that it was traveling close to 70 miles per hour off the New Jersey coast, which meant that it was traveling only slightly more slowly than the velocities of the particles of air within the storm. Therefore, the cold air did not have time to sweep around the center.

Let us consider what will happen to a distinct front, the southern end of which is being approached by a hurricane. According to all writers [1] the hurricane moves so that the anticyclone will be on the right. This means that, if there is a well defined trough between the Bermuda HIGH and the HIGH to the west, the hurricane will move up the eastern side of this trough. If there is a sharp front in this trough, the front first will move westward as a warm front as the winds increase in velocity from the east. If gradient winds existed, the front would naturally keep moving around the hurricane. However, this does not happen because there is a frictional effect to take into account. This frictional effect causes the winds to flow across the isobars at a certain angle, depending on the pressure gradient and the roughness of the surface.

A close approximation to this angle can be determined from Rossby's and Montgomery's data.[2] First we must determine the roughness parameter over the ocean. The expression for this is $z_0 = s\epsilon$ where s is a nondimensional factor, and ϵ is the roughness element. Prandt [3] suggests a tentative value of 1/30 for s. Wüst [4] states that the roughness parameter (z_0) for the Baltic is between 3.2 and 4 centimeters. However, in dealing with the hurricane, we can safely assume that the roughness element, ϵ, is at least 3 meters; therefore, z would be one-thirtieth of this or 10 centimeters.

The wind speeds in the hurricane averaged about 25 meters per second. Referring to figure 8 on page 18 in Rossby's and Montgomery's paper, we see that the angle at which the winds would flow across the isobars at this

[1] Especially Mitchell, C. L. West Indian Hurricanes and other Tropical Storms of the North Atlantic Ocean, MONTHLY WEATHER REVIEW SUPPLEMENT No. 24.
[2] Rossby, C. G., and Montgomery, R. B. The Layer of Frictional Influence in Wind and Ocean Currents, p. 5, *Papers in Physical Oceanography and Meteorology*, published by Massachusetts Institute of Technology and Woods Hole Oceanographic Institution.
[3] *Ibid*, p. 5.
[4] *Ibid*, p. 19.

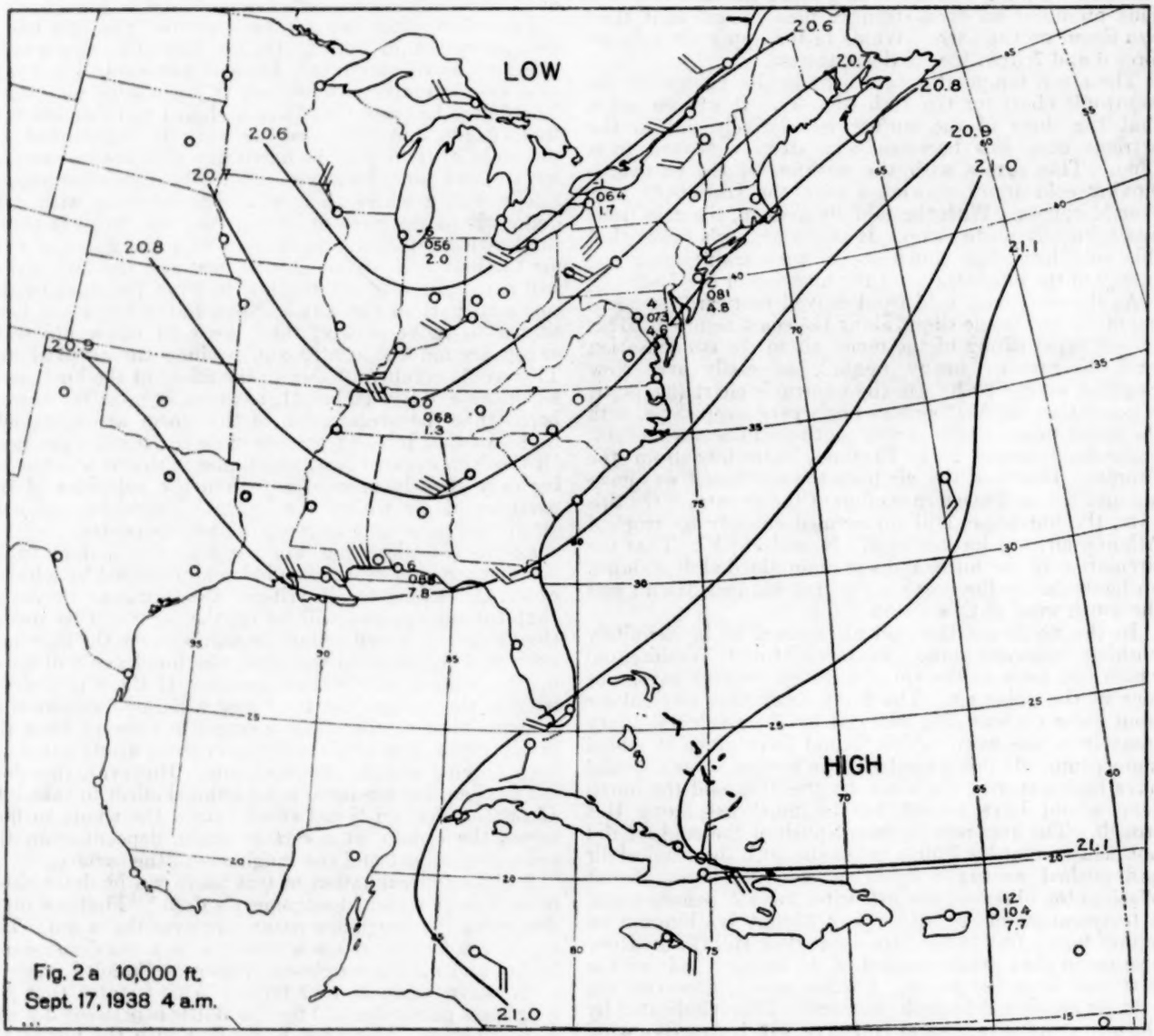

Fig. 2a 10,000 ft.
Sept. 17, 1938 4 a.m.

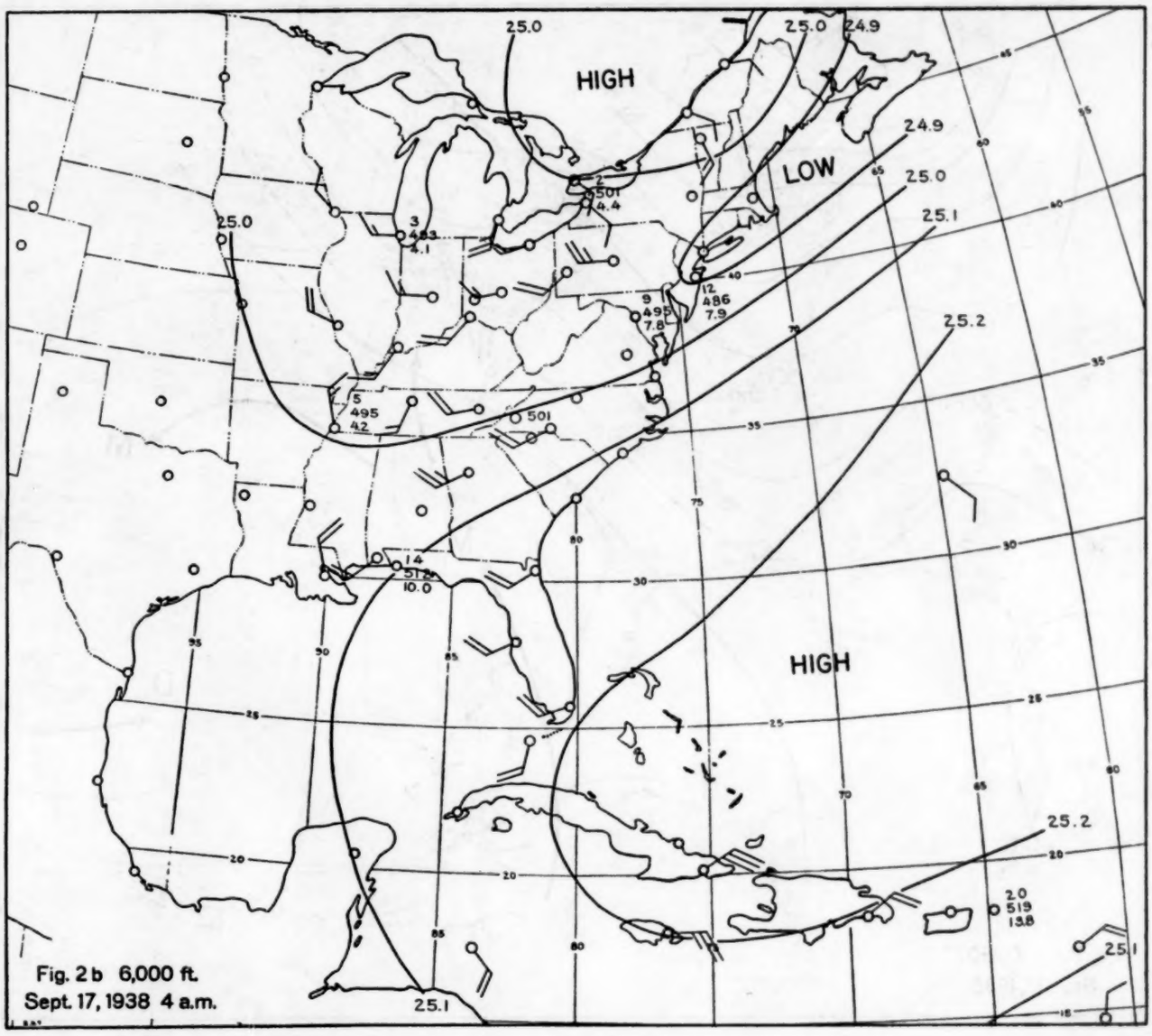

Fig. 2 b 6,000 ft.
Sept. 17, 1938 4 a.m.

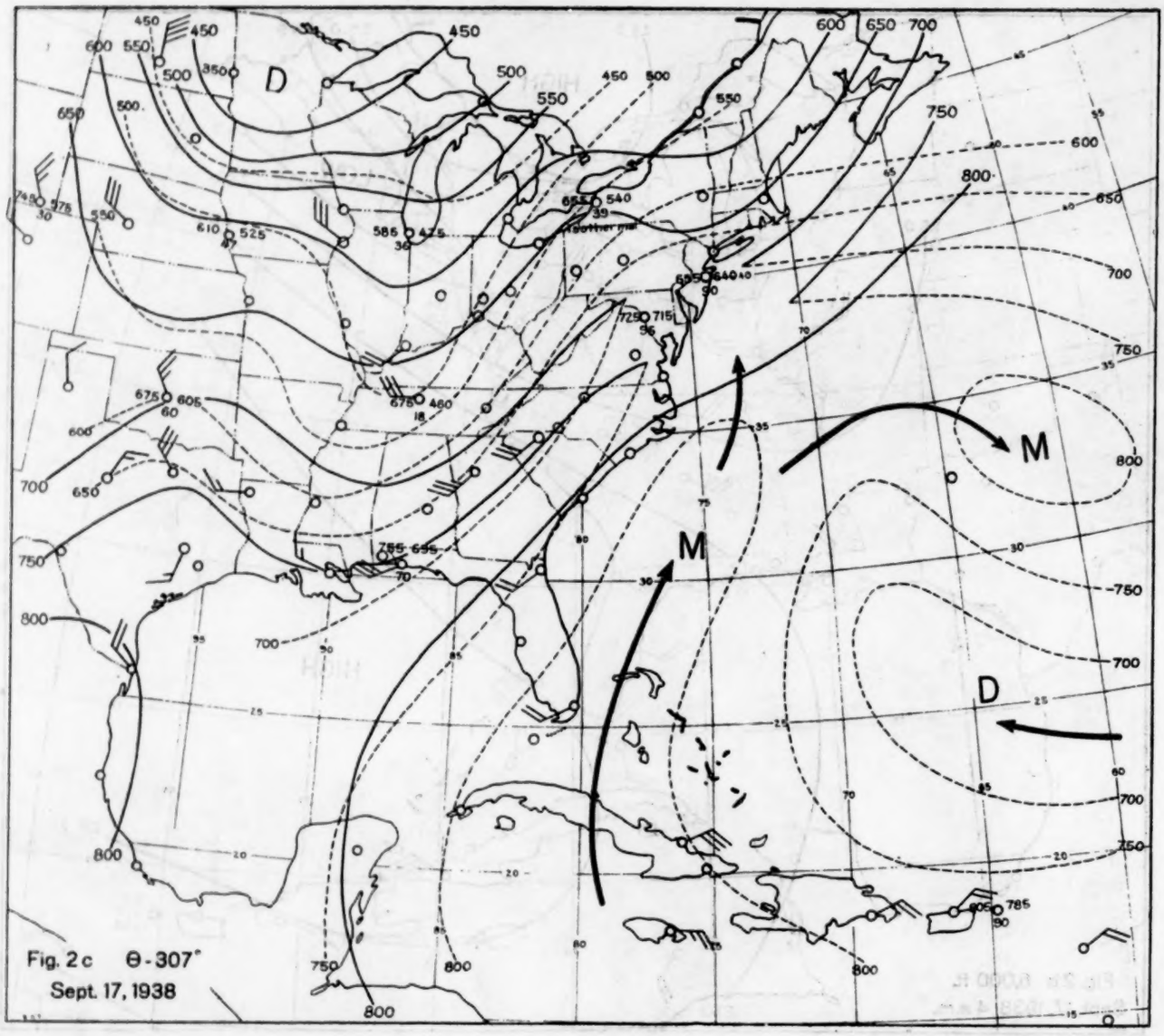
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Fig. 2c θ-307°
Sept. 17, 1938

speed is 21°. Over land, the roughness parameter increases to about 70 to 100 centimeters, so that the angle at 25 meters per second is about 28°. These are for straight-line flow, but according to Haurwitz [5] this would be the same for curved flow at the earth's surface.

Thus the front would move westward as a warm front until it reached a position with reference to the isobars north of the LOW center where the front would cross the isobars at an angle of 21°, and at this point, therefore, the front would remain stationary. Slightly closer to, but still north of, the center, we see that the northward-moving storm would bring the front into a position where it would cross the isobars at less than 21° (point B, fig. 27). At this point the winds would be flowing across the isobars at an angle greater than that between the front and the isobars; therefore, the front at the ground will move eastward as a cold front.

It can be shown from figure 27 that in the case of a front oriented north and south, the farther west from the center the front is, the farther north of the east-west axis will the front start moving eastward as a cold front. The line AB represents the position south of which the winds would shift to slightly west of north, so that any north-south front would change from a warm to a cold front along the line AB. The angle that this line forms with the east-west axis is equal to the angle at which the air flows across the isobars. This is true because we have two right triangles ABC and BCD. The angles ABC and CDB are the right angles. The angle at C is the same for both triangles, and therefore angle CAB is equal to angle DBC.

Above it was stated that the southern end of this front would at first move westward as a warm front. As the line AB intersected the southern end of the front, it would become a cold front. As the southern end of the front approached the rear of the storm, the winds would become more and more normal to it and the front would move, therefore, more and more rapidly eastward.

STRUCTURE OF THE STORM NEAR WASHINGTON

During the evening of the 20th, the autographic records indicated that the cold front passed Cape Hatteras. At the same time the hurricane was ENE of Jacksonville. As the hurricane moved northward during the night, the front must have moved westward as a warm front, but, as indicated by the thermograph record, Hatteras was never again in the warm air.

At 7:30 a. m., on the 21st, the hurricane was 140 miles ENE. of Hatteras. At this time there was a very definite front to the north of the hurricane center, as indicated by the three ships east of Cape Henry. Two of them farthest to the east report ENE. winds with temperatures of 77° and 76°; the other ship, a short distance to the west, reports a north wind with a temperature of 67°.

Now about this time some very valuable upper-air information was secured from the radiosonde observation made by the United States Navy at Anacostia, D. C., and two pilot-balloon ascents made by the Weather Bureau at the Wasington Airport, Arlington, Va. At the time the regular pilot-balloon ascent was supposed to be made, there was inclement weather, but improved weather conditions made it possible to take a balloon run at 7:52 a. m.

This upper-air sounding (fig. 28) showed very rapidly increasing northerly winds up to 800 meters, and then a decrease just as rapidly up to 2,400 meters. Between 2,000 meters and 2,400 meters the winds shifted from NNW. to S. It appears incongruous that the wind at 2,400 meters should be from the south with the center of the hurricane 350 miles to the southeast of Washington. An explanation of this will be shown presently. Above 2,400 meters, the winds again increased rapidly to 3,200 meters, then less rapidly to a top velocity of 60 miles per hour from the SSW. at 4,400 meters. The radiosonde ascent (fig. 29) taken 2 hours earlier shows cool air at low levels and warm moist air aloft, with two distinct inversions: One at 1,600 meters, the other at 3,300 meters. The decreasing wind velocity comes at 1,600 meters and the strong south wind at 3,200 meters. The author's first impulse was to put the front at the second inversion where the wind shifts. Of course, this would assume that the hurricane at this level was completely wiped out and that the pressure gradient was in agreement with a strong south wind.

However, there were several objections to this. In the first place, by placing the front at 3,100 meters it would mean that the slope of the warm front would be 1/90, which is rather steep for a warm front surface. Also, the potential temperature of the warm front surface seems to be too high for the corresponding surface temperature of the warm sector. The potential temperature at the top of the lower inversion is close to the potential temperature of the warm-sector temperatures.

A greater objection, of course, is to eliminating the hurricane at 10,000 feet. The fact that the very low pressure must exist even at 10,000 feet is known by use of the hypsometric equation. If we assume that the central pressure is 28.00 inches, and that a psuedo-adiabatic lapse rate exists, the pressure at 10,000 feet would be 19.55 inches, which is 1.12 inches lower than the observed pressure at that height over Washington. H. Wexler carried the computations further and found that, in order to obtain a pressure at the center in keeping with the strong southerly winds at Washington (20.88 inches at 10,000 feet), the mean temperature of the air column from the ground to 10,000 feet would have to be 58° C. higher than that given by the assumption of pseudo-adiabatic equilibrium! The pressure of 20.88 inches corresponded to the isobar that was originally drawn across the center in our first attempts to account for the strong south wind at Washington. However, such a mean temperature in the column of air is impossible.

From this reasoning, and from the winds at Washington, the hurricane appears to be a separate cyclonic circulation *within* a stream of air from the south, as depicted by figure 30. Believing, then, that there is a separate cyclonic circulation, it is now possible to put the warm front at the lower inversion at Washington, which means, therefore, that the warm air must have swung cyclonically around the hurricane and come in from the north and north-northwest. The air from the north above the warm front is moving at a much less rate of speed than the cold air below. There is, then, the difference in velocity necessary to maintain a frontal slope with the cold air lying as a wedge west of the warm current.

Using the Washingon upper-air data, it is possible to draw a theoretical cross-section. This is shown in figure 31. On this cross-section, the winds are drawn with the orientation such that north is the top of the cross-section and east is to the right, and so on.

The first inversion is the front between the polar air and the tropical air. The second inversion would be the front between the tropical air of different trajectories. This storm is contrasted to the November 1935 hurricane which was in about the same position, but moving south and south-southwestward off the south Atlantic coast.

[5] Haurwitz, B. On the Change of Winds with Elevation under the Influence of Viscosity in Curved Air Currents, p. 202, *Gerlands Beiträge zur Geophysik*, Leipzig, 1935.

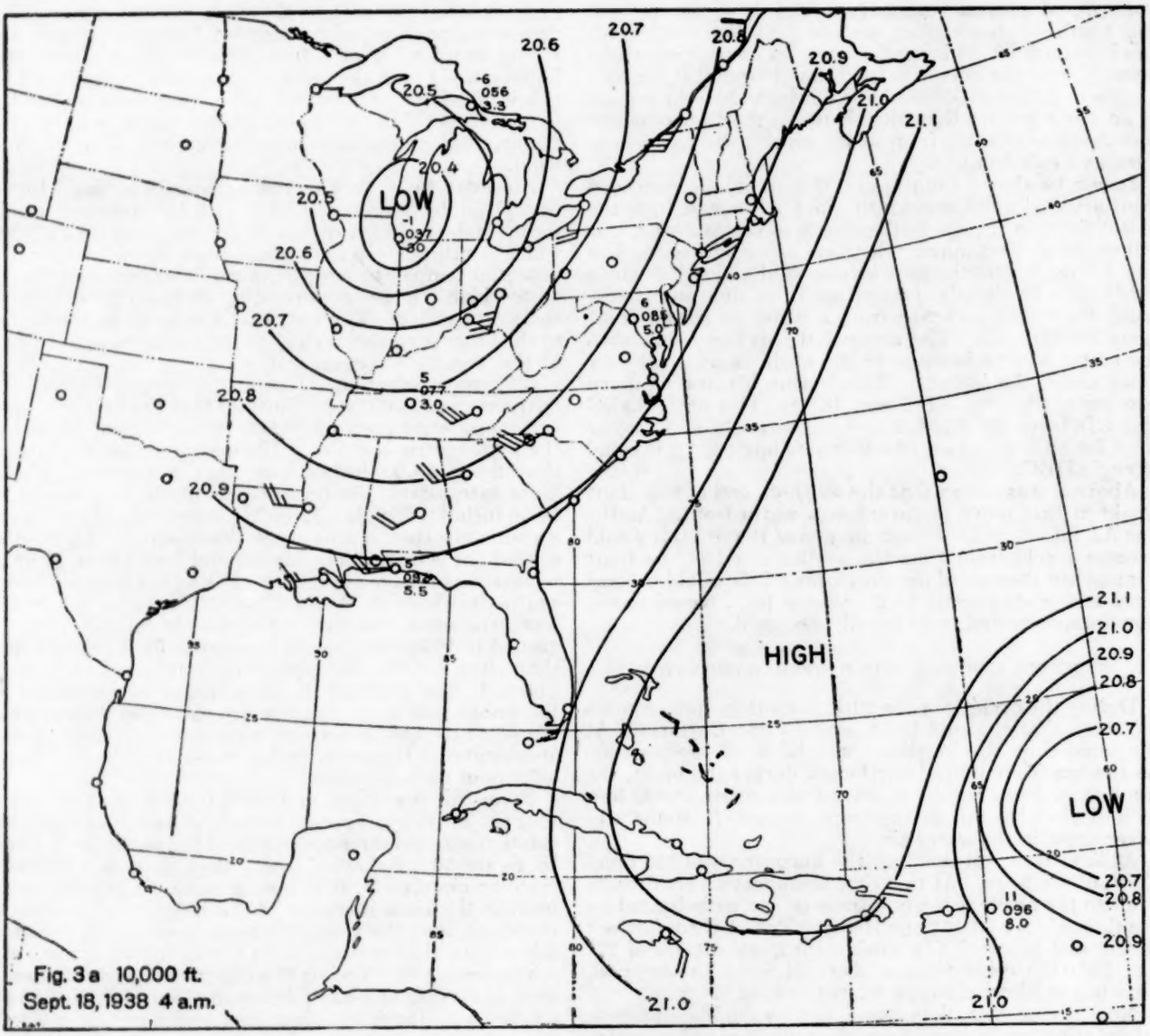

Fig. 3 a 10,000 ft.
Sept. 18, 1938 4 a.m.

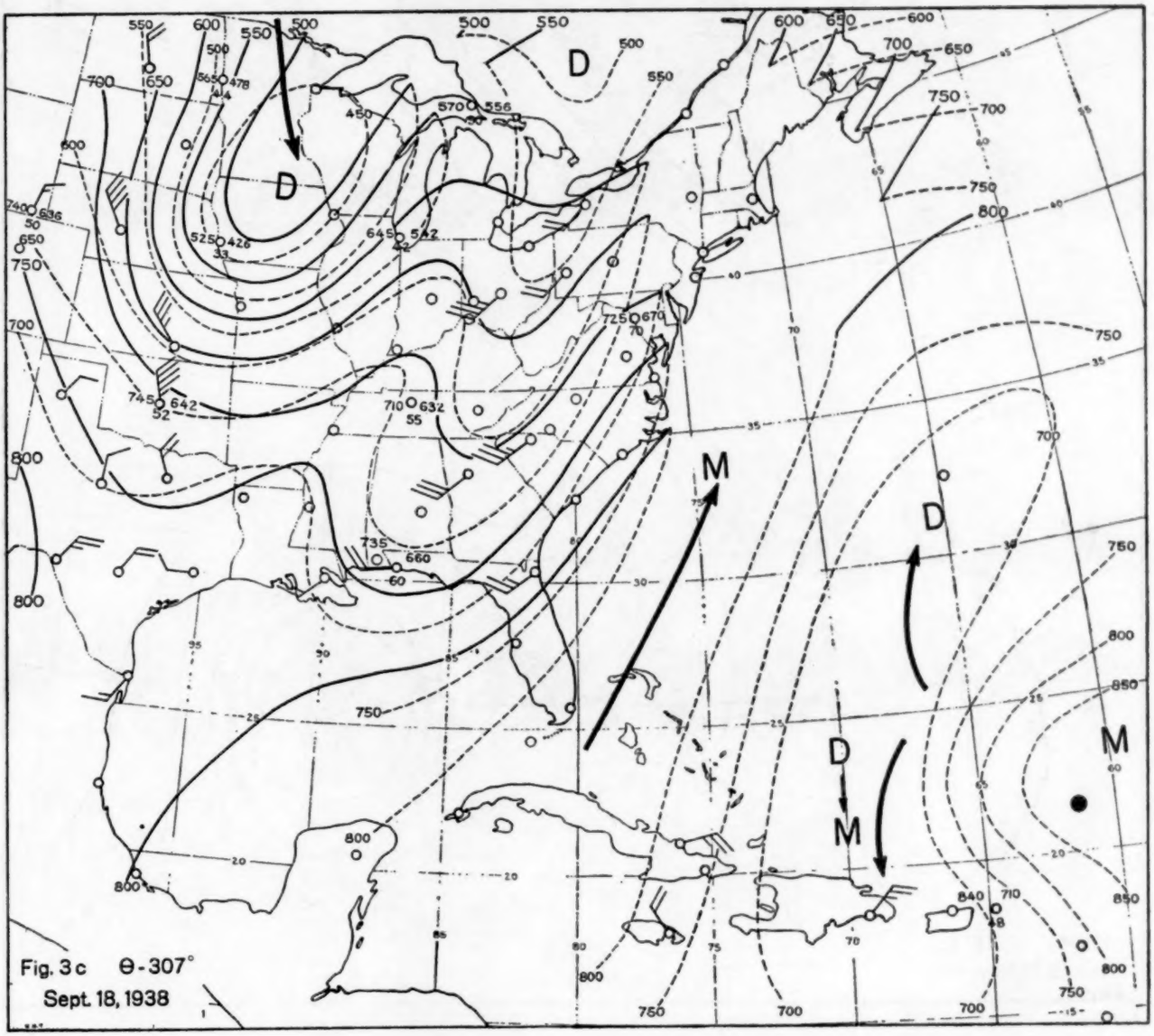

Fig. 3c Θ-307°
Sept. 18, 1938

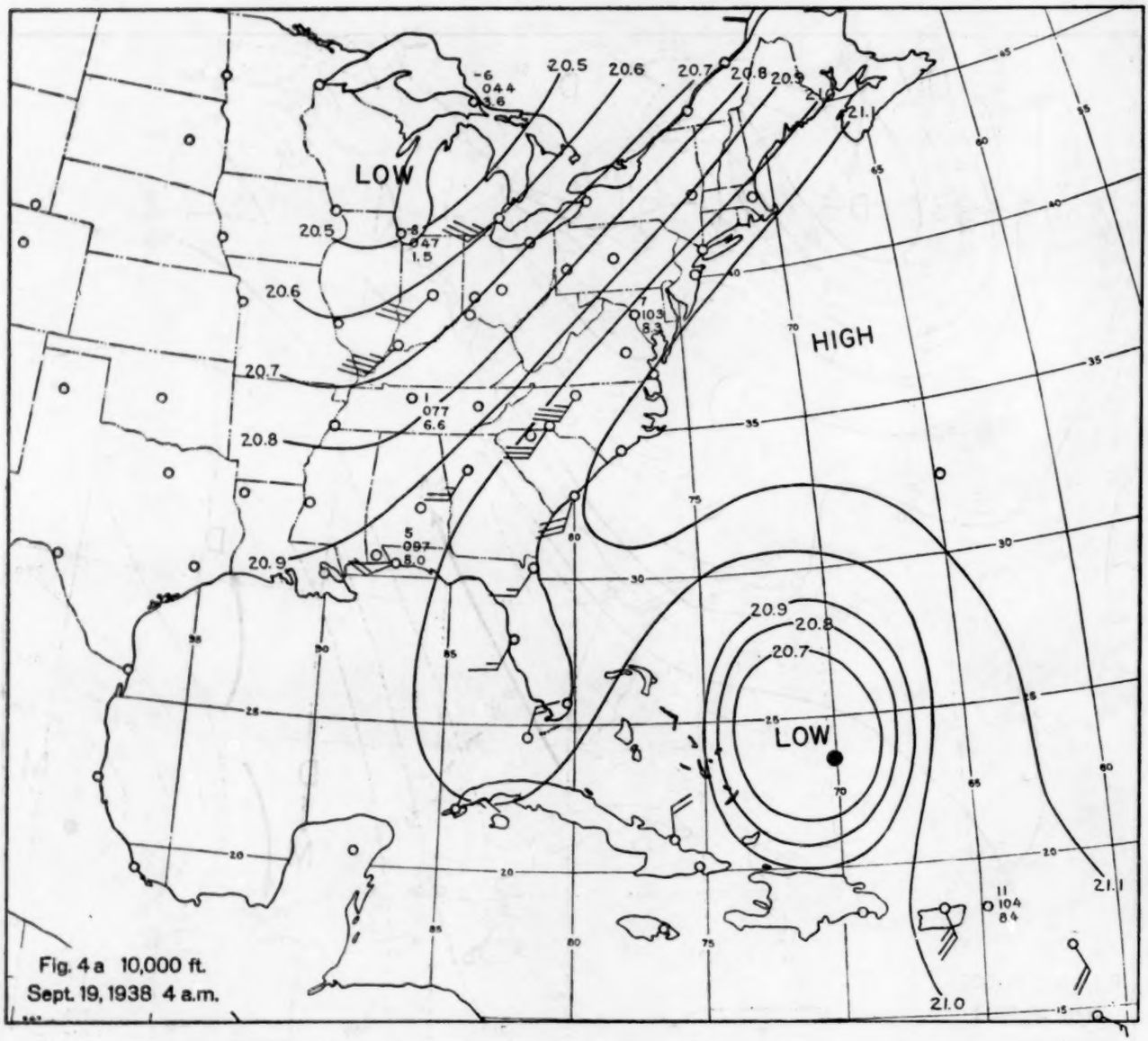

Fig. 4 a 10,000 ft.
Sept. 19, 1938 4 a.m.

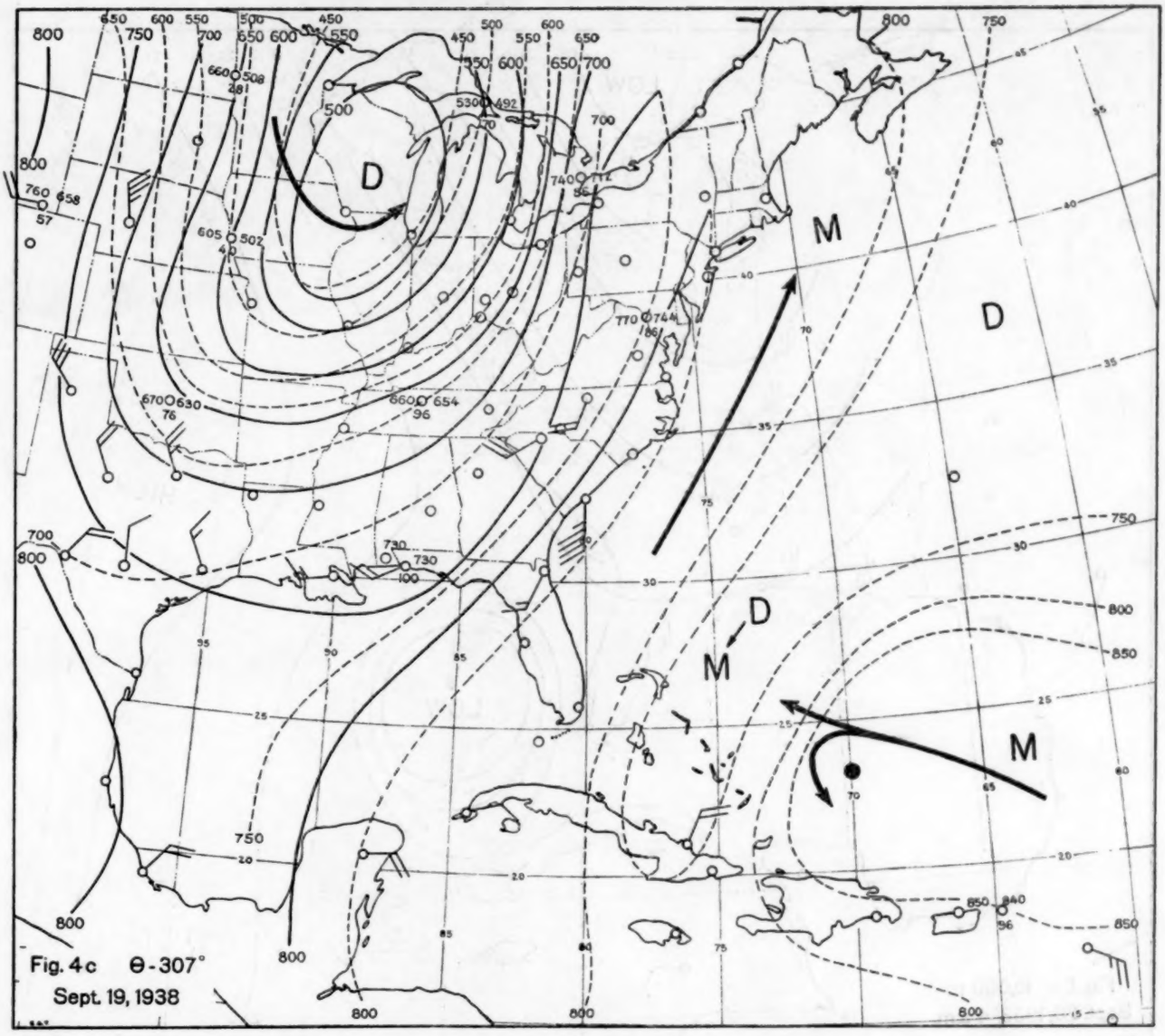
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Fig. 4c Θ-307°
Sept. 19, 1938

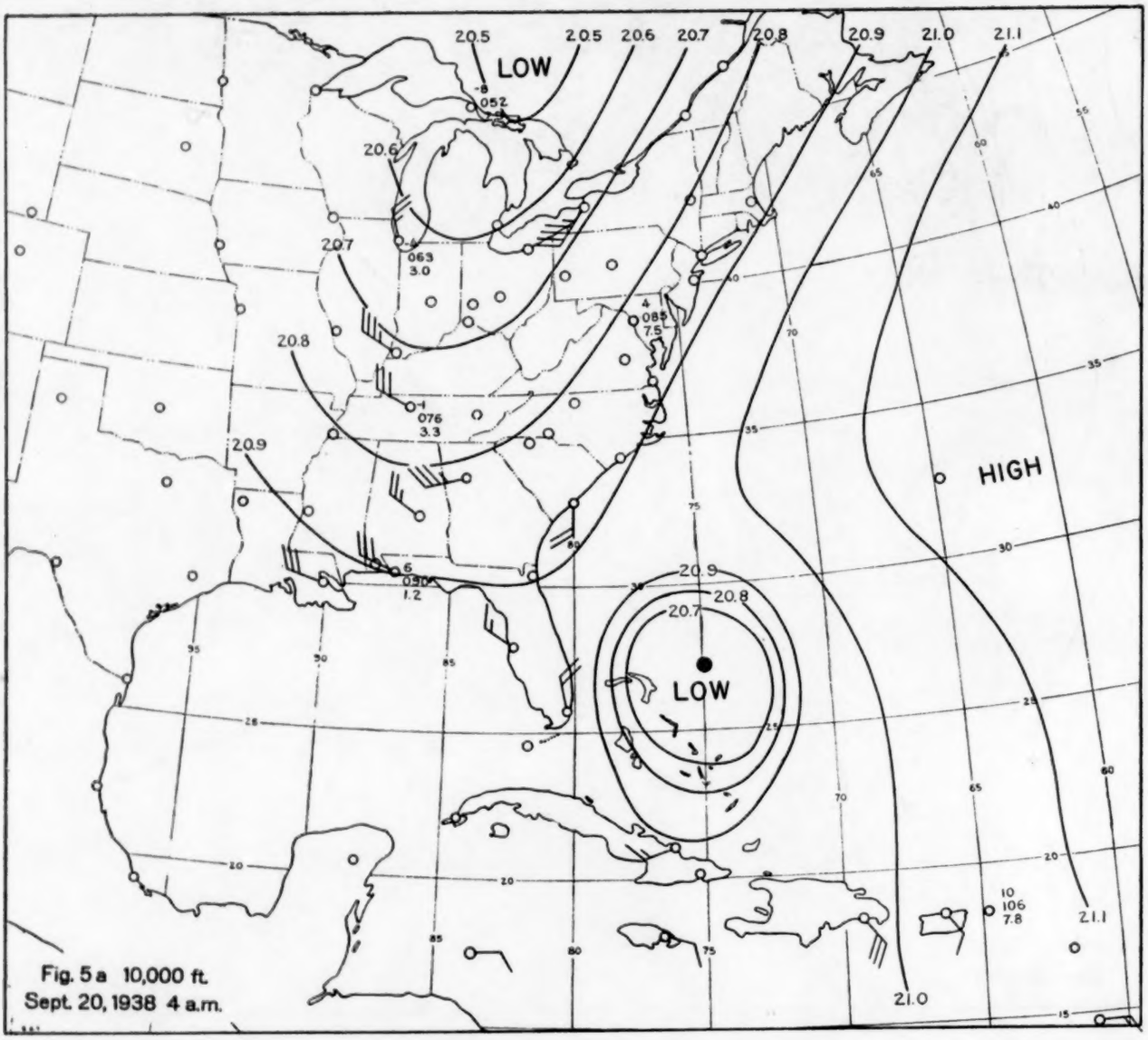

Fig. 5 a 10,000 ft.
Sept. 20, 1938 4 a.m.

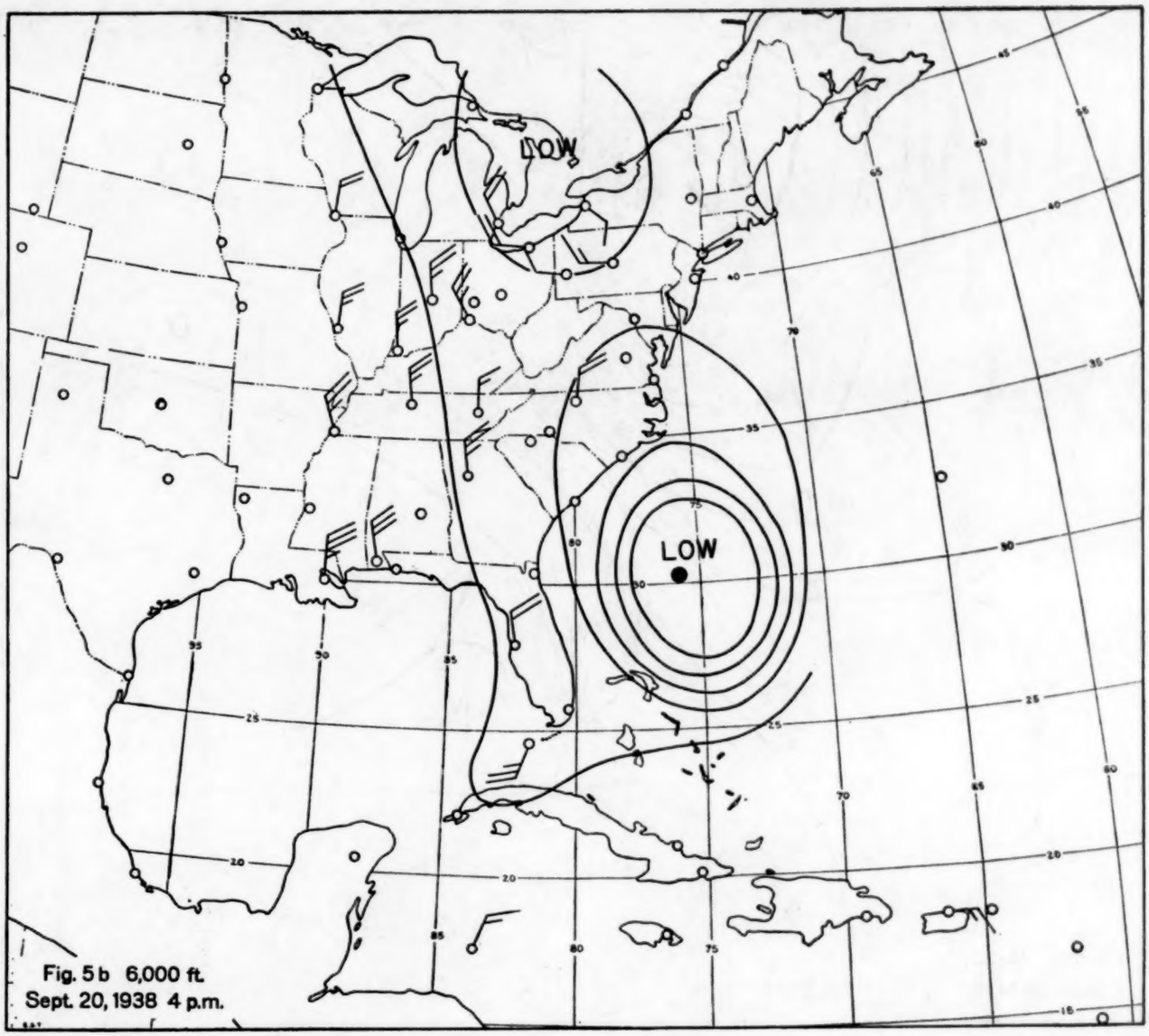

Fig. 5 b 6,000 ft.
Sept. 20, 1938 4 p.m.

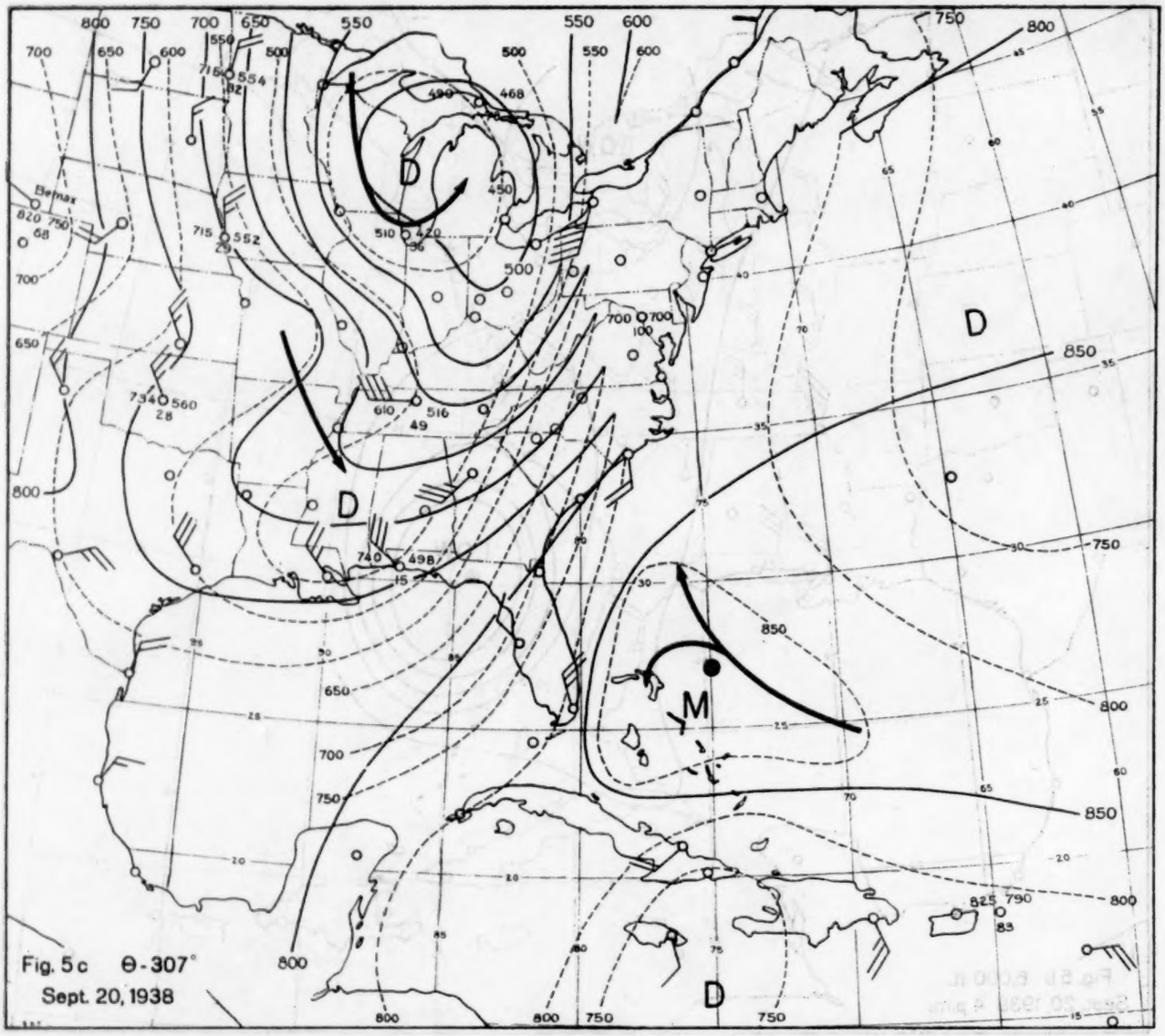
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Fig. 5c θ-307°
Sept. 20, 1938

Byers [6] pointed out that the winds aloft over the eastern part of the country during this time were northerly.

HOURLY COURSE OF THE STORM

We return now to the surface analysis which will be carried through from 11 a. m. of the 21st to 12 a. m. of the 22d. These maps are constructed from data furnished by hourly airways teletype sequence reports and the autographic records of the regular Weather Bureau stations.

From 7:30 a. m. to 11 a. m. (figs. 12 and 13), the hurricane had shown rapid movement northward and at 11 a. m. was east of Norfolk, Va. The warm front had passed west of New Haven and Hartford. During the next 2 hours, the storm continued to accelerate in its movement so that by 1 p. m., according to figure 32, it was traveling at the rate of approximately 70 miles per hour, and was about 100 miles east-southeast of Atlantic City. Winds were already increasing along the southern New England coast.

Attention is drawn to the observation made at Mitchel Field at this hour. The wind is northeast, force 7 Beaufort, with a temperature of 70°. On figure 33, note how the temperature kept dropping slowly until 11 a. m., then rose sharply with the warm-front passage around noon. It is seldom that such distinct warm-front passages occur even in the winter. It is also interesting to note the discontinuity between Mitchel Field and Floyd Bennett Field, which is only 18 miles to the west. At Floyd Bennett the wind was north-northwest, force 7 Beaufort, and the temperature was 60° F.

At 2 p. m., the center was east of Lakehurst. There are no important changes, except that the wind reached hurricane force at Block Island.

The center reached the south shore of Long Island shortly before 3 p. m. The clear calm area experienced in the "eye" of a hurricane was reported from many points on Long Island. E. S. Clowes of Bridgehampton states that "clear, fairly calm interval occurred at Patchoque and at Port Jefferson." Brooks [7] reports that the calm center was experienced as far west as Brentwood and as far east as Mattituck. Thus, the diameter of the calm center is at least 43 miles, and if we are to believe there were 50 minutes of calm at Brentwood, then the "eye" must have been 50 miles wide, because the storm at that time was traveling at the rate of 60 miles per hour. The diameter of the "eye" seems to have become smaller as it moved into New England, because Hartford, which is west of the longitude of Mattituck, Long Island, did not experience the calm conditions. It is suggested by Brooks that the increased friction over land was responsible for the "dilation" of the central "eye."

Even though the east-west axis of the hurricane had not passed Mitchel Field by 3 p. m., the cold air had already moved in from the west. The wind at this time was north-northwest and the temperature had dropped to 59° F. This sudden temperature drop is very distinct on the thermograph record (fig. 33).

All the stations in approximately the same longitude and the same position, with respect to the storm, as Mitchel Field had similar traces on their thermograph records. Although Pittsfield, Mass., did not have a thermograph, the hourly sequences prove that the same front passages occurred there.

Miss Shirley Farr of Brandon, Vt., sent to the Weather Bureau her barograph and thermograph records, which were exceedingly helpful in the analysis of this storm. The thermograph trace (fig. 34) was very valuable in determining the front passages, and it will be noted that the trace shows the same pattern as was found at Mitchel Field.

Shortly after 3 p. m. the cold front east of the center passed Block Island. Unfortunately, the thermograph was upset by the high winds; however, the spotted record (fig. 35) shows the temperature dropped sharply near 3 p. m.

At 4 p. m. (fig. 18) the center had passed into southern Connecticut. The cold front east of the center was now north of the east-west axis, as is shown by the observations taken at Providence. The lowest pressure occurred there at the same time that it occurred at New Haven; also, there was a distinct temperature drop.

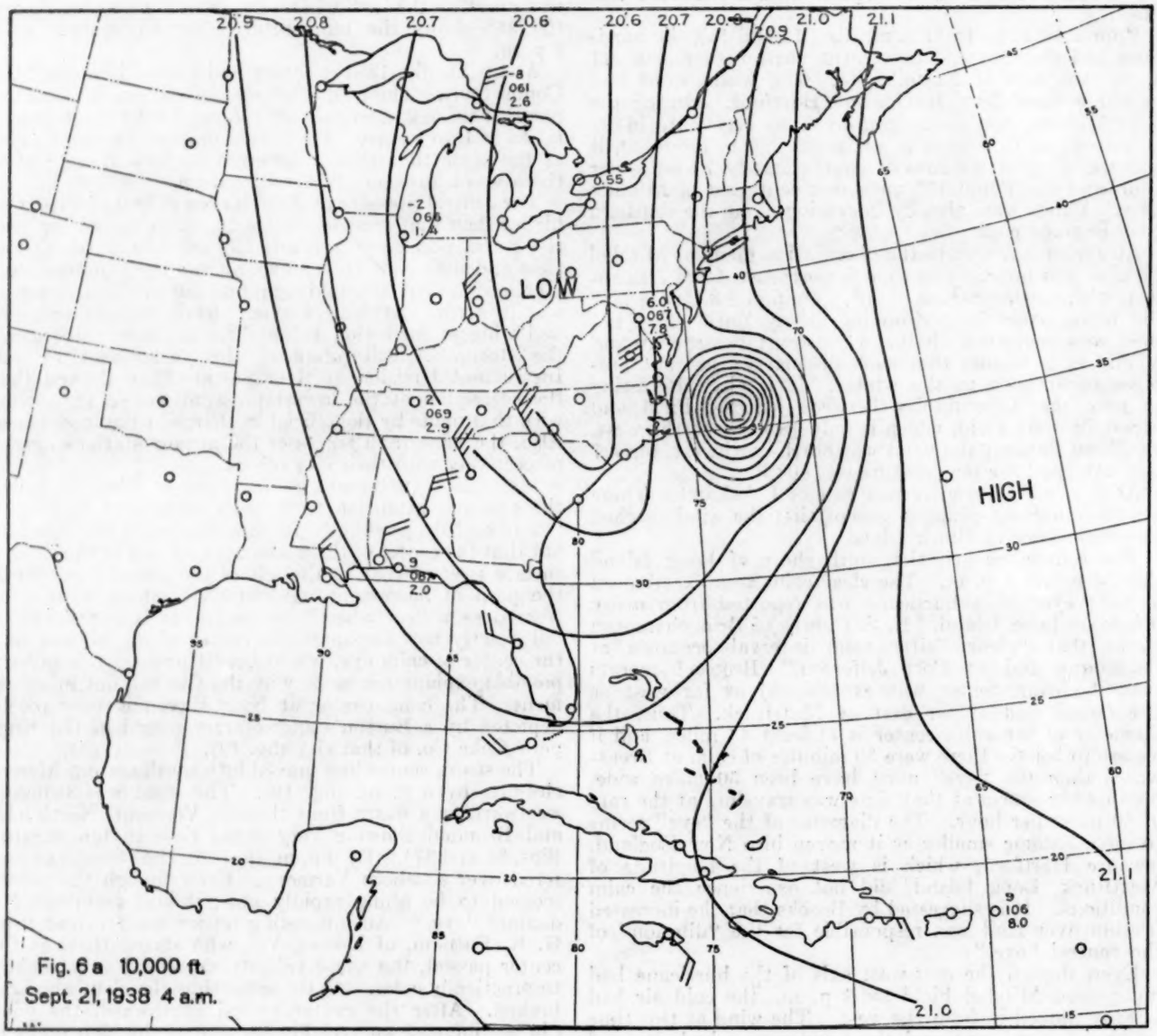
The central pressure at New Haven of 28.11 inches was higher than that reported at Hartford. Considering that the storm was moving practically straight north at the time and that New Haven experienced the calm eye that Hartford did not, it would seem that one of these pressures was in error. At New Haven, the barograph pressure had a higher correction value than any other station in the storm. A calibration of this instrument by the Instrument Division at the Central Office showed that the correction at the lowest pressure was in agreement with that made by the official in charge at the local office. Also, the barograph traces of the airport stations agreed respectively with their city offices.

Mr. Elliot, meteorologist for Eastern Airlines, called the author's attention to Brunt's reference [8] to Shaw's "cartwheel depression." In this discussion Shaw points out that the center of the winds with respect to the earth's surface is somewhat to the left of the lowest pressure in the path of movement. Because this storm cannot be treated as a "cartwheel" depression, it is impossible to tell exactly how far apart the center of the isobars, and the center of calm eye, would be. However, this gives a possible explanation as to why the two are not in agreement. The calm center at New Haven is very nicely depicted by a Burton's anemometer record of the Kopper's Coke Co. of that city (fig. 49).

The storm center had moved into southwestern Massachusetts by 5 p. m. (fig. 19). The front was swinging westward as a warm front through Vermont, Northfield, and Brandon showing very rapid rises in temperature (figs. 34 and 37). By 6 p. m. (fig. 20), the storm was centered over southern Vermont. Even though the center seemed to be filling rapidly now, it still maintained a distinct "eye." An interesting report was received from G. R. Putnam, of Dorset, Vt., who stated that, as the center passed, the wond velocity decreased very rapidly to practically calm. At the same time the clouds became broken. After the center passed northward, the wind did not increase appreciably because of the high range of mountains to the southwest. However, it did become overcast again.

The cold front in the eastern sector of the storm passed Concord, N. H., at about this time. The thermograph record (fig. 38) shows a very noticeable discontinuity. The temperature which was steady at 70° F. suddenly dropped to 64° F. at 6 p. m. The storm was now curving more to the northwest as indicated by its position at 7 p. m. (fig. 21). The sudden drop in temperature at

[6] Byers, H. R. The Meteorological History of the Hurricane of November 1935, MONTHLY WEATHER REVIEW, vol. 63, No. 11, p. 322.
[7] Brooks, C. F., Hurricanes into New England, *The Geographical Review*, January 1939.
[8] Brunt, David. Physical and Dynamical Meteorology, 1934, p. 296.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20.8
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20.6
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LOW
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21.1
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Fig. 6a 10,000 ft.
Sept. 21, 1938 4 a.m.

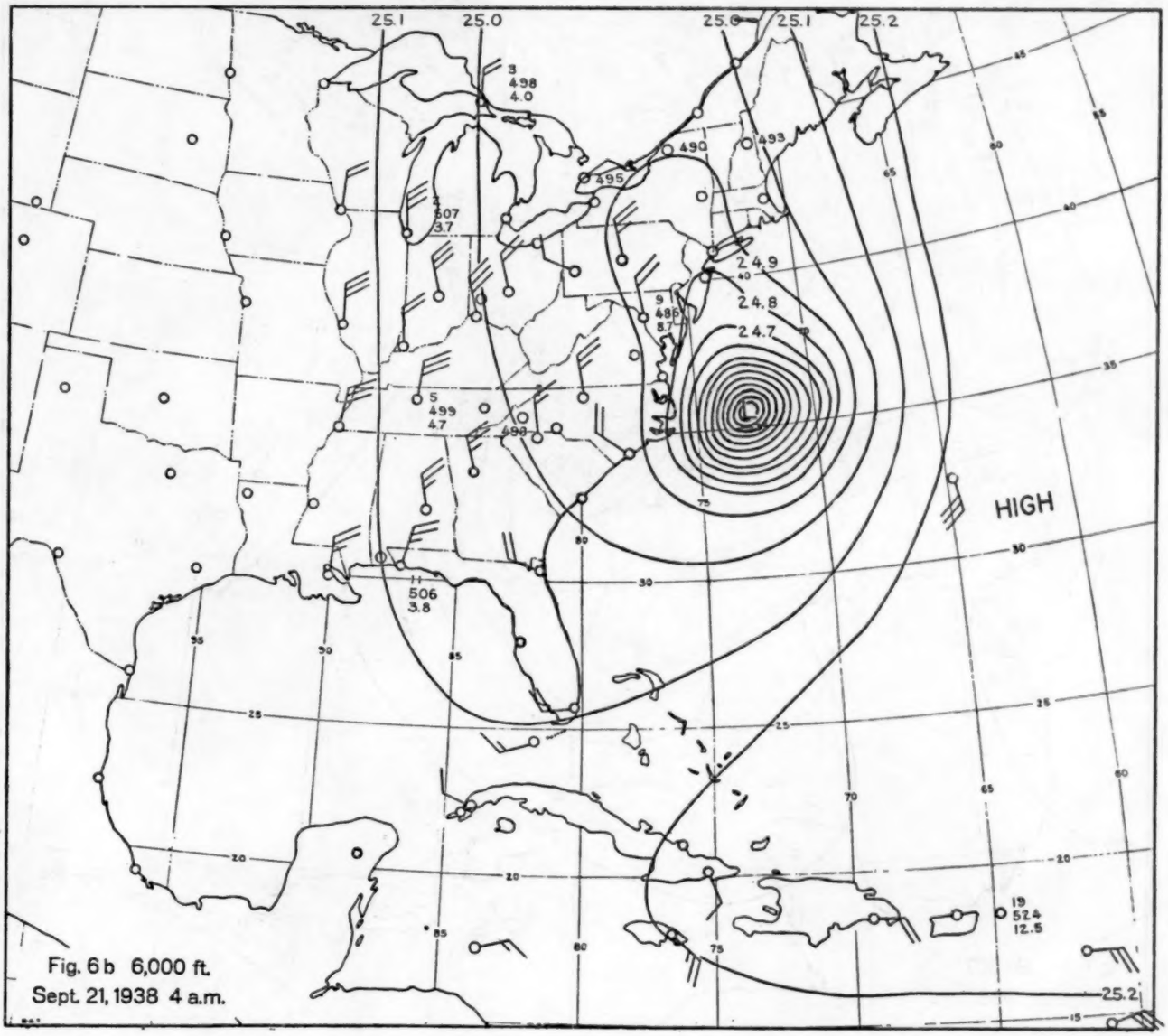

Fig. 6b 6,000 ft.
Sept. 21, 1938 4 a.m.

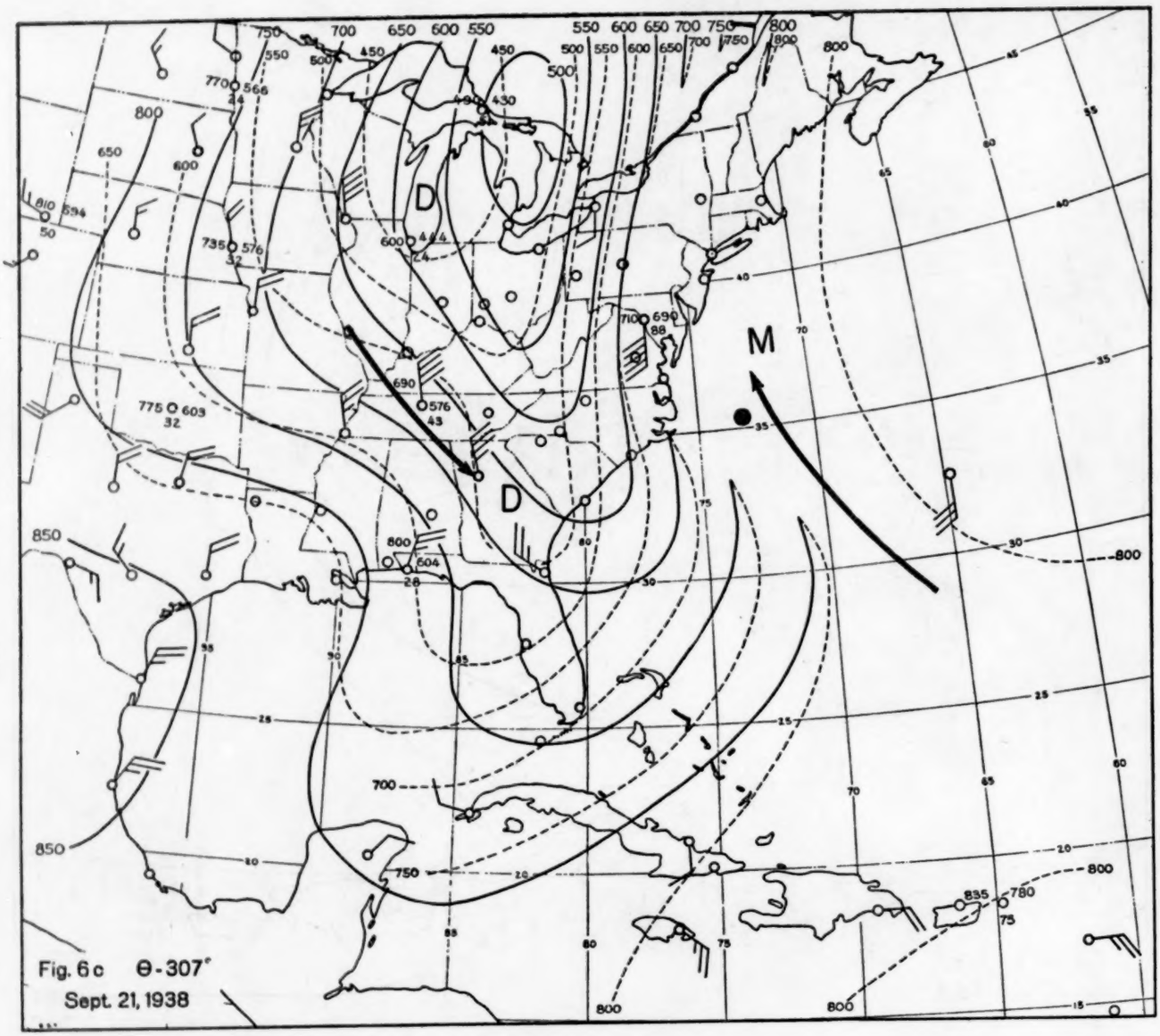
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Fig. 6c Θ-307°
Sept. 21, 1938

Northfield was due to the cold front passing from the southeast.

Burlington experienced warm-sector weather for a short period of time with the warm-front passage shortly before 8 p. m. (fig. 39). As the center was now decelerating, the cold front in the eastern sector of the storm was overtaking the warm front to the west. Therefore, Burlington was passed shortly before 9 p. m. by the cold front from the southeast, and not as other stations in the same longitude, by the cold air coming in from the west. With the cold front from the southeast overtaking the warm front to the west, occlusion was bound to take place. At what definite time this occurred cannot be stated, but the synoptic chart of 9 p. m. (fig. 23) shows the occlusion taking place at the southern tip of the frontal system. The occlusion process was probably fairly rapid after this time because of the noticeable deceleration of the storm. At 10 p. m. (fig. 24) the whole northeast section of the country was now in the cold air. The cold front passed east of Eastport with a decided wind shift from southeast to southwest and a corresponding drop in temperature. The 7:30 a. m. map of September 22 showed this same cold front very distinctly just west of Halifax and Anticosti Island.

MAINTENANCE OF ENERGY

An important question at this point relates to why the storm maintained its energy so long after it passed inland. Those who are acquainted with hurricanes in the Gulf of Mexico realize that upon striking land, the hurricane usually dissipates very rapidly. This is due to: (1) The cutting off of the moisture which supplies energy in the form of latent heat of condensation, and (2) the increased friction over land. Of course, exactly the same things were operating in the New England hurricane, but there was another type of energy available which maintained this storm. After the hurricane acquired the deep polar air mass, there was further energy supplied by the potential energy of air-mass distribution. Therefore, after the storm reached the supply of cold air to the west, though the moisture content was reduced, the potential energy of mass distribution was still available to overcome some of the frictional influence. Another reason why the storm maintained its energy was that internal friction within the air was reduced. For a hurricane that moves into the Gulf States, the circulation aloft is usually light. In the case of the New England hurricane, however, the storm moved into a region having a strong cyclonic circulation aloft. Thus the internal friction within the air itself was greatly reduced. A rough schematic diagram (fig. 40) was drawn to depict the energy and friction forces and the changes that took place in them from the time of the storm's genesis until it passed into Canada. This diagram shows how the latent heat of condensation was the main source of energy at first and that the frictional effect was small. When the hurricane moved north of latitude 30° N., it acquired the fronts and polar air of this region. With the cold air on the western side, some of the latent heat of condensation was cut off. However, this was offset by energy of air-mass distribution.

When the center reached New England, the friction effect increased rapidly, which reduced the energy and caused the rapid filling.[9] However, the potential energy of air-mass distribution was still sufficient to overcome some of the friction effect, so that filling was not as rapid as usual.

[9] This is treated more fully by Raymond Wexler in a paper for his master's thesis, entitled, "The Filling of the New England Hurricane of September 1938."

EXPLANATION OF MINOR TROUGH

One of the most interesting and most puzzling phases of this storm was the distinct trough which passed across New Jersey, New York City, western Long Island, and southwestern Connecticut. Figures 41, 43, 44, 45, 46, 47, and 48 all show this dip in the barograph trace. Figure 41 is a barograph trace of Eastern Airlines at Newark, N. J., furnished to us by William Warren. Figure 42 shows a wind shift at Sandy Hook from west to northwest and back to southwest between 4 p. m. and 5 p. m. A meteorologist who did not have the opportunity to study this phenomenon minutely would have expected that this trough was indicative of a cold-front passage. If this were the case, this front and the trough would have to move from west to east with the path of air particles.

The time of the passage of this trough was plotted on the same chart as the time-distance graph of the storm center (fig. 32). It will be noted that the trough moved northward at the same rate of speed as the main center. This movement was approximately at right angles with the wind directions. Therefore, it could not have been a front at the surface.

Another possibility to explain the trough is the passage of a cold front aloft. However, this seems unlikely because the circulation aloft was adverse for such a frontal passage from the south. Also, if it were a cold front aloft, New Haven would not have experienced this trough effect.

A. F. Spilhaus has suggested that this trough might be explained by another cyclonic circulation within the main storm. This seems to be a reasonable explanation considering the movement corresponded to that of the center of the storm. This cyclonic eddy did not have a separate circulation, because it was too close to the main storm. However, it did cause a definite wind shift. A slight shift in wind from southwest to northwest occurred through New Jersey and Long Island. At New Haven, where there was not a wind shift, however, the wind did decrease in velocity as the low trough approached and increased after the trough passed. This is shown between the time of 6:30 to 7 p. m. (5:30 to 6 p. m. eastern standard time) on figure 23.

Thus, one of the most unusual and, from the viewpoint of the meteorologist, one of the most interesting storms passed into history, to be known as the New England hurricane of September 21, 1939. Actually, it was not a *tropical* hurricane in the strict sense of the word after it passed north of latitude 30° N., because in this area it was transformed into an extra-tropical storm, with a definite frontal structure and two distinct air masses—tropical maritime and polar continental. However, it was a cyclone which unfortunately maintained its hurricane intensity and, because of the peculiar temperature and wind distribution in the upper atmosphere, instead of following its normal course it moved straight northward over one of the most densely populated sections of the country.

The author wishes to take this opportunity to thank the following people who assisted in the development of this paper: The members of the Air Mass Section of the Weather Bureau, especially Clarence Gilbert, Pat Harney, George Mitchell, David Stevlingson, and Arthur Thomas for aiding in the construction of many of the charts; Wilson Reed at the Weather Bureau Office at Newark for furnishing many valuable data; William Warren of Eastern Air Lines, Miss Shirley Farr of Brandon, Vermont, and C. F. Brooks of Blue Hill Observatory, and the Koffer's Coke Company of New Haven, Conn., for giving us the use of their records; R. D. Elliott for his very helpful suggestions; and Harry Wexler and H. R. Byers for their many valuable suggestions and helpful comments.

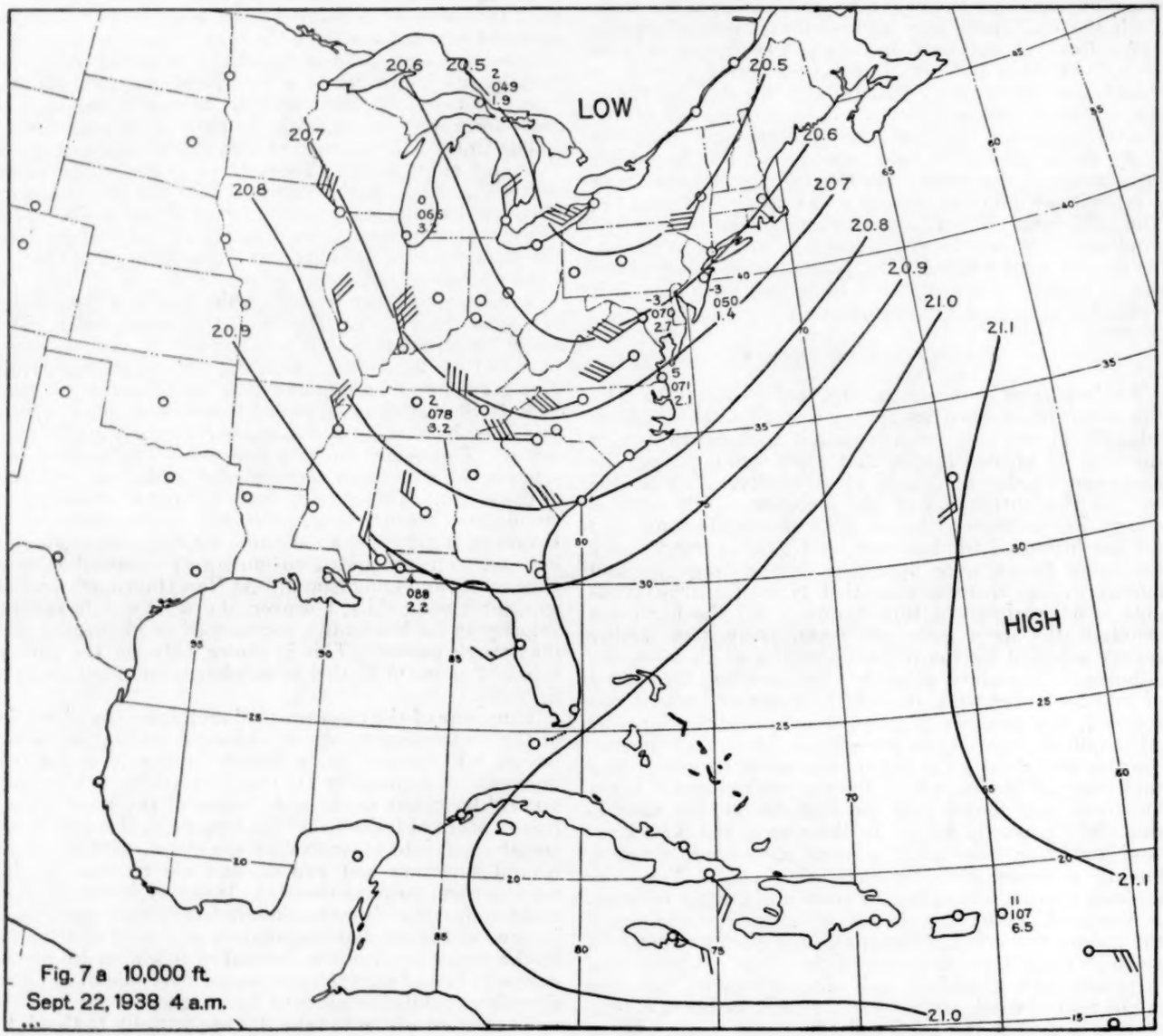


Fig. 7 a 10,000 ft.
Sept. 22, 1938 4 a.m.

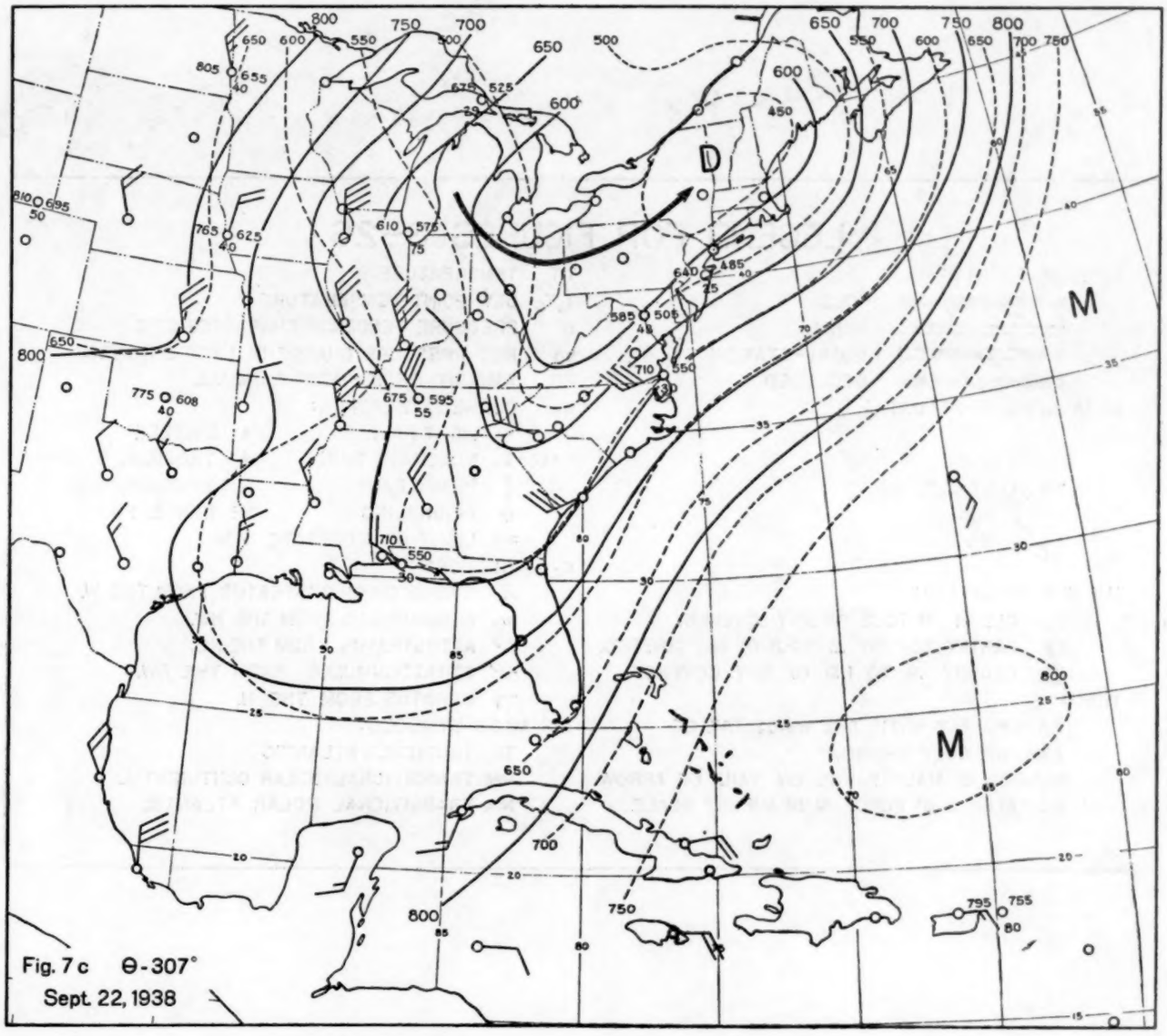


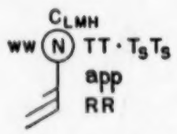
Fig. 7 c Θ-307°
Sept. 22, 1938

LEGEND FOR FIGURES 8-26

SURFACE FRONTS:

- COLD
- WARM
- QUASI-STATIONARY
- OCCLUDED

ARRANGEMENT OF DATA:



N - SKY CONDITION:

- ○ CLEAR 0 TO .2 OF SKY COVERED.
- ◑ PARTLY CLOUDY .3 TO .8 OF SKY COVERED.
- ● CLOUDY .9 TO 1.0 OF SKY COVERED.

WIND:

ARROWS FLY WITH THE WIND; TAIL OF ARROWS ONLY SHOWN.
NUMBER OF HALF BARBS ON TAIL OF ARROW INDICATES WIND FORCE IN BEAUFORT SCALE.

- TT TEMPERATURE
- T_sT_s DEW POINT TEMPERATURE
- a PRESSURE TENDENCY CHARACTERISTIC
- pp NET PRESSURE CHANGE IN LAST 3 HOURS
- RR AMOUNT OF 12-HOUR RAINFALL
- ww CURRENT WEATHER:
  - • LIGHT RAIN
  - •• or ⁝ MODERATE RAIN
  - ⁝ HEAVY RAIN
  - ▽ SPRINKLING
  - = LIGHT OR MODERATE FOG
  - , DRIZZLE
  - ϟ TROPICAL STORM
  - ⍼ THUNDERSTORM
  - ≡ DENSE FOG
- C_{LMH} CLOUDS:
  - 2 CIRRUS OR CIRROSTRATUS FROM THE W.
  - ∽ ALTOCUMULUS FROM THE NW.
  - ⌓ ALTOSTRATUS FROM THE NE.
  - ⌄ STRATOCUMULUS FROM THE SW.
  - ¬ STRATUS FROM THE N.
- AIR MASS SYMBOLS:
  - T_A TROPICAL ATLANTIC
  - N_{PC} TRANSITIONAL POLAR CONTINENTAL
  - N_{PA} TRANSITIONAL POLAR ATLANTIC

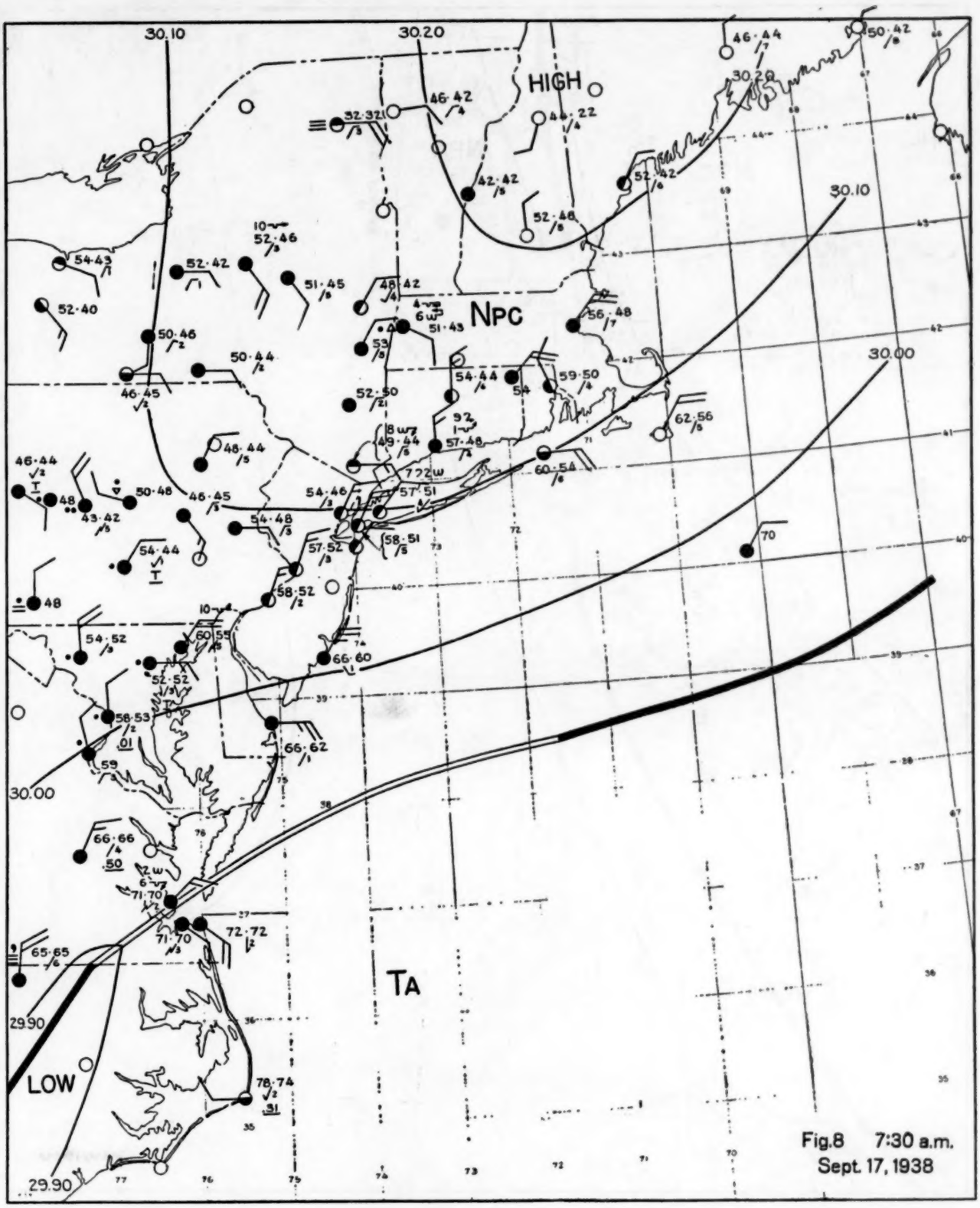


Fig.8 7:30 a.m.
Sept. 17, 1938

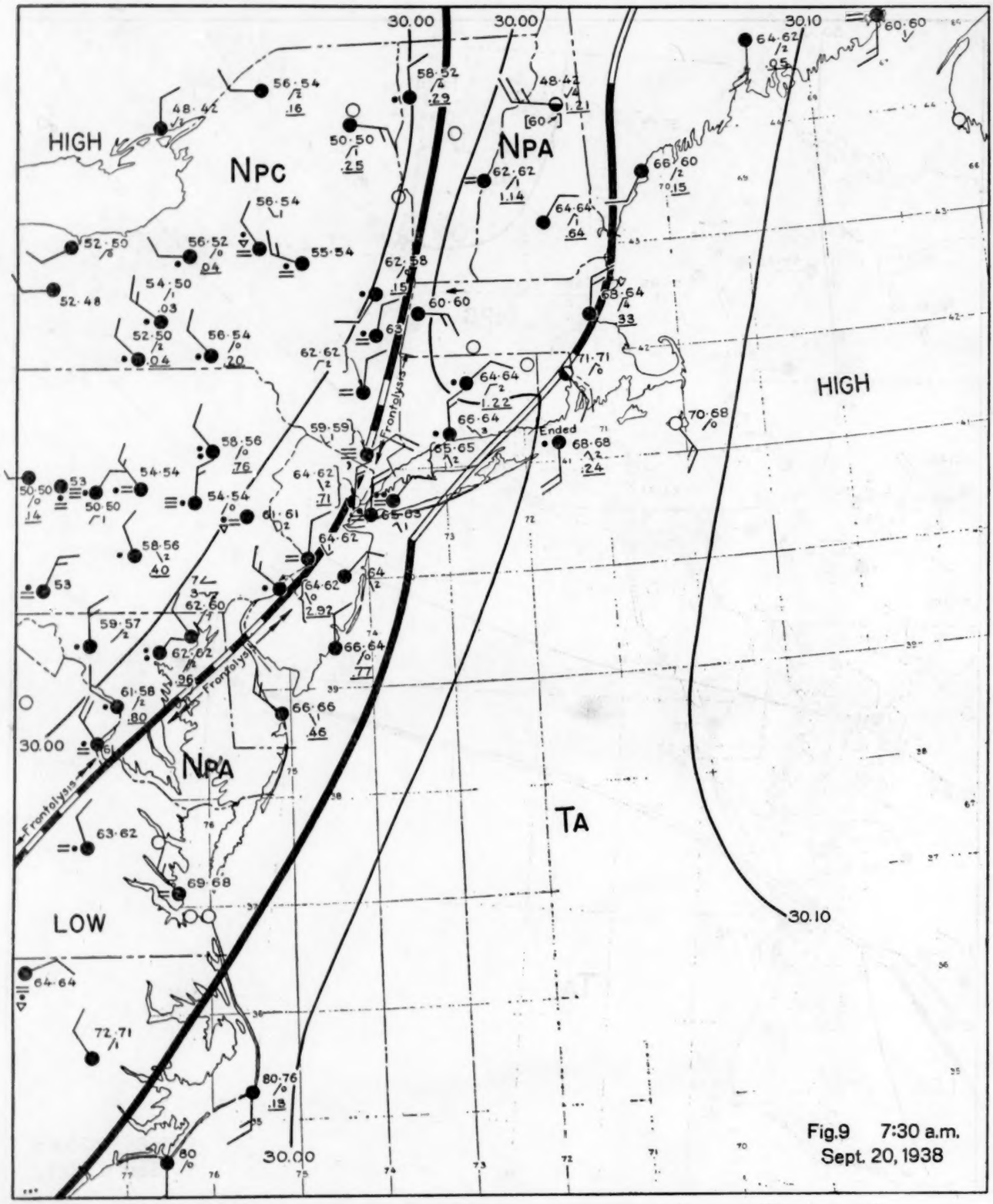


Fig.9 7:30 a.m. Sept. 20, 1938

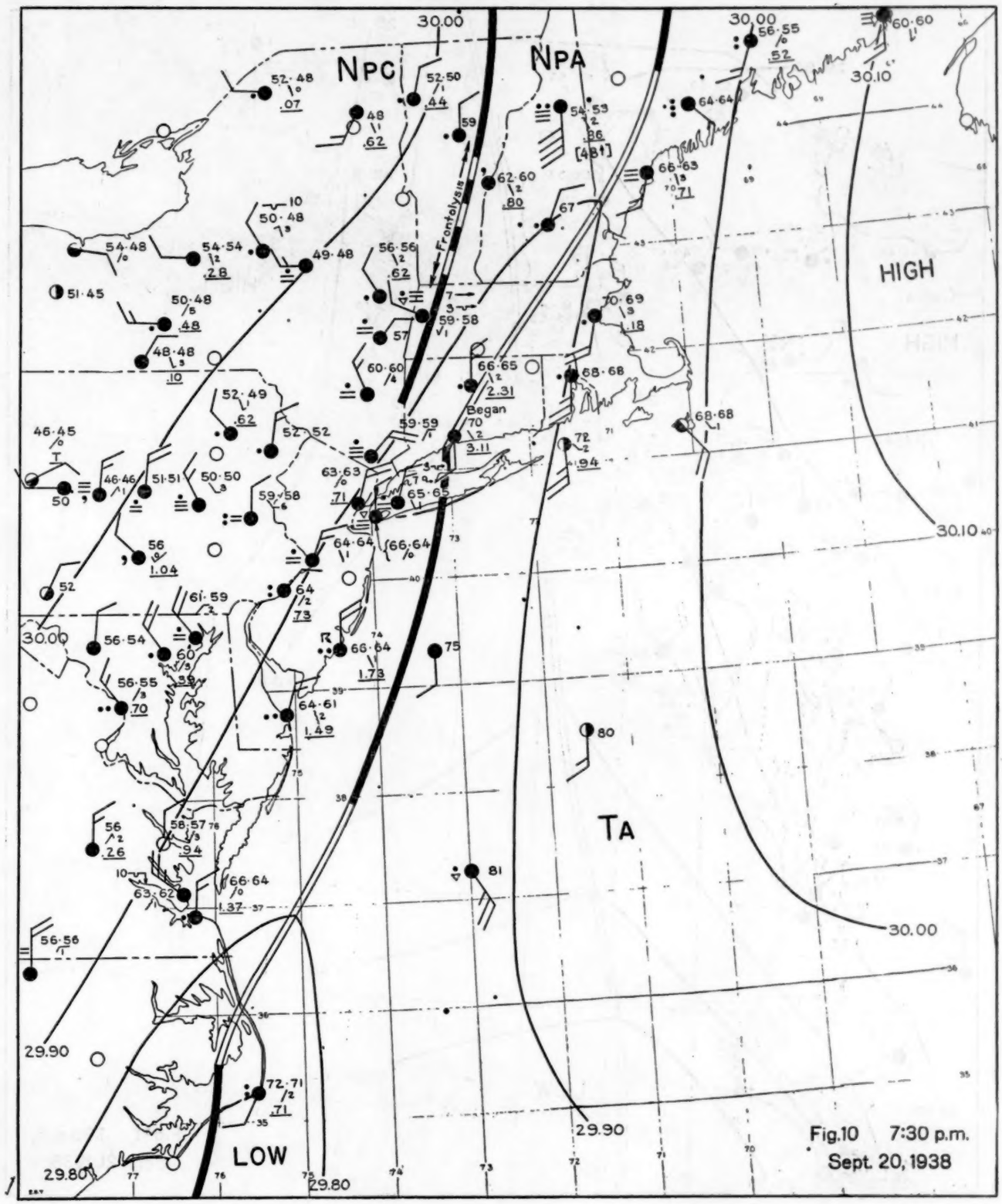


Fig.10 7:30 p.m. Sept. 20, 1938

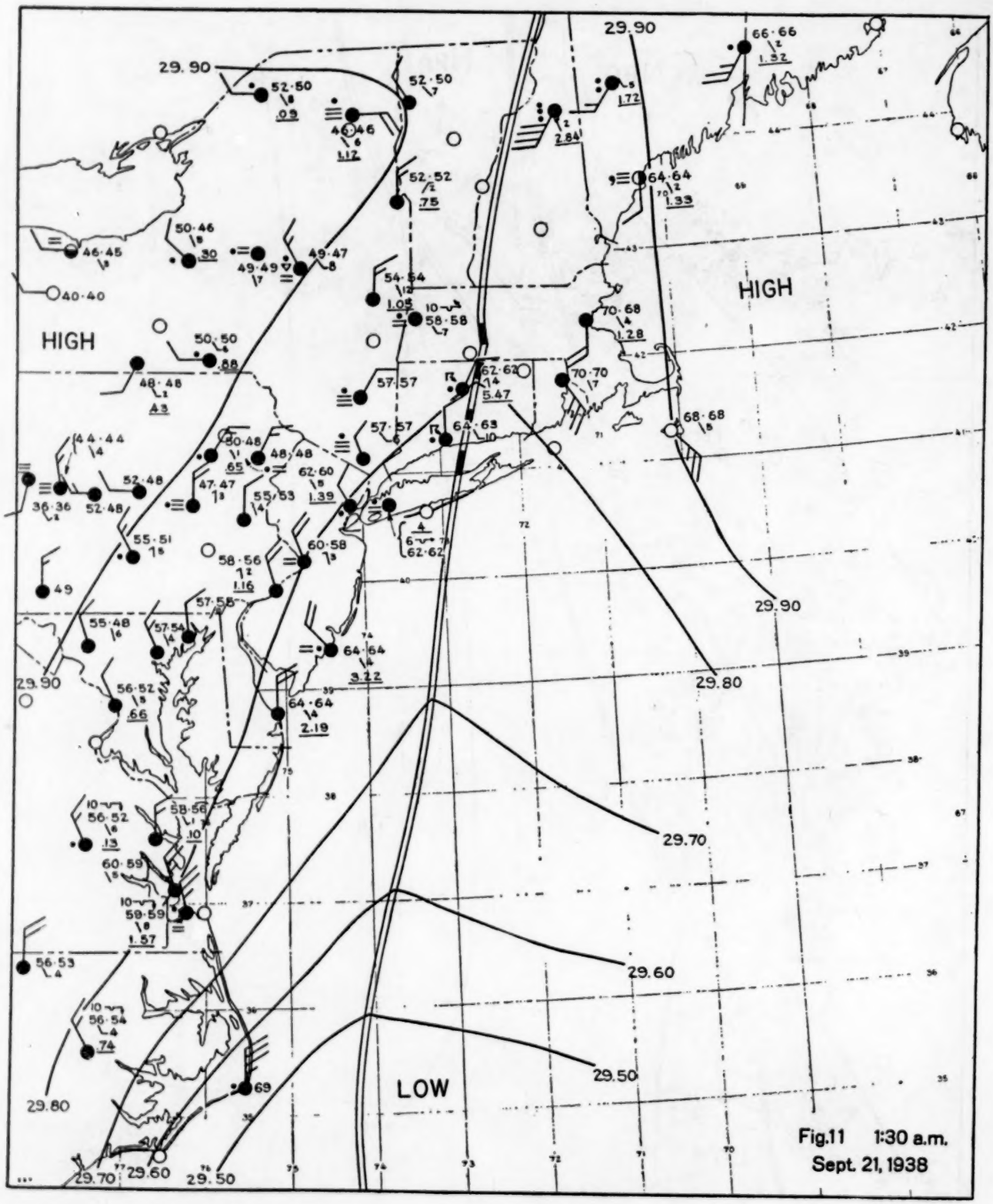


Fig.11 1:30 a.m. Sept. 21, 1938

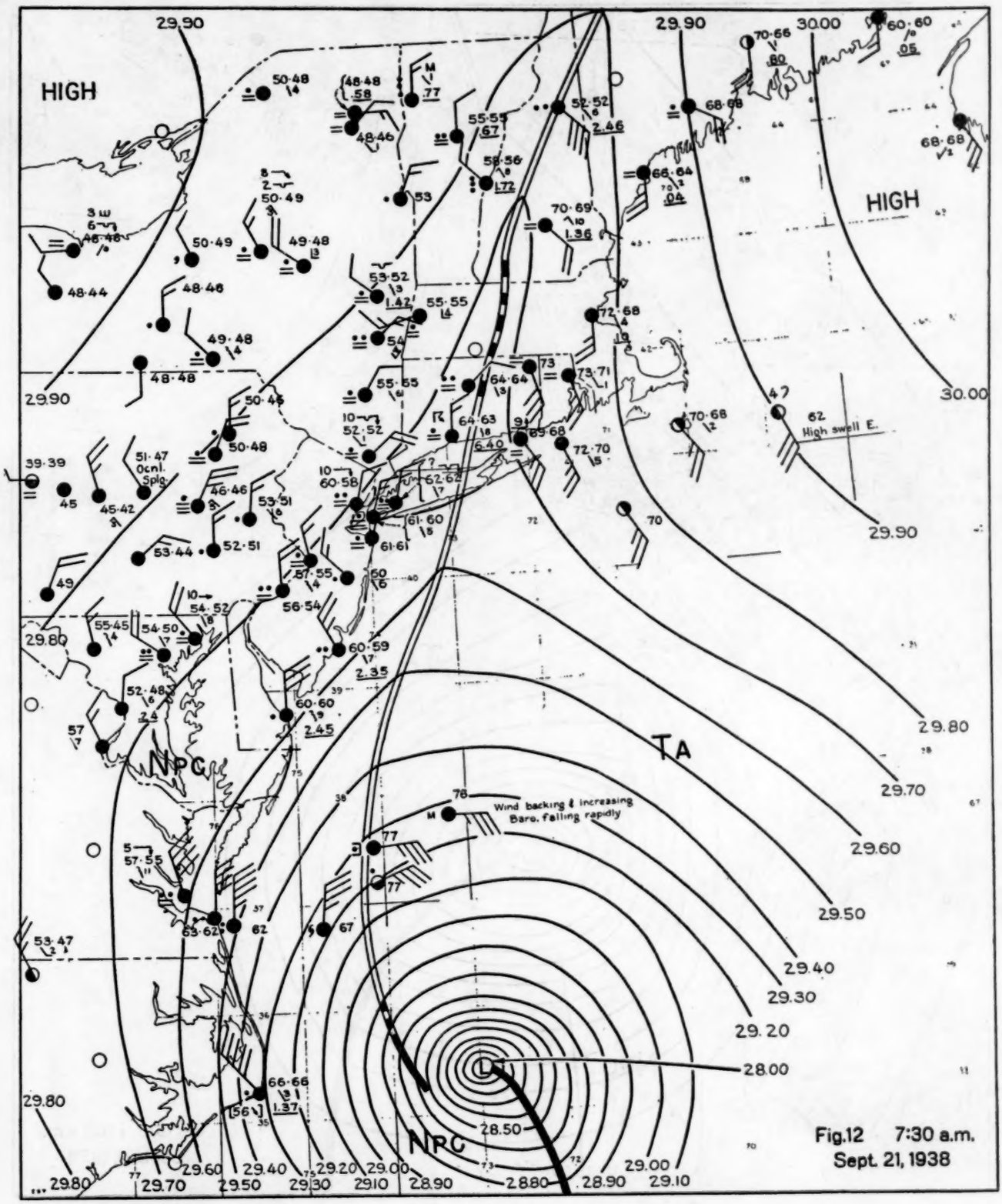


Fig.12 7:30 a.m. Sept. 21, 1938

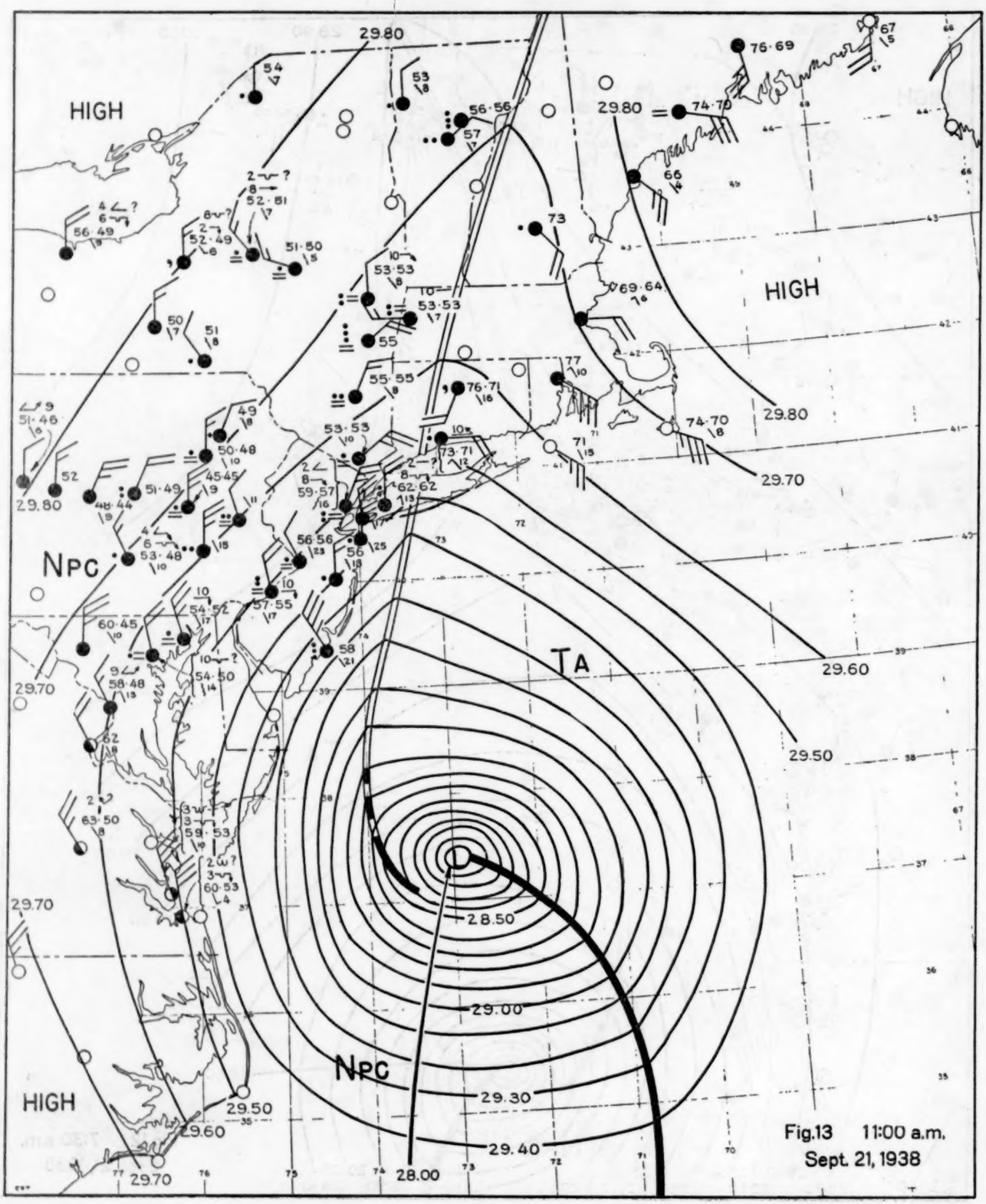


Fig.13 11:00 a.m. Sept. 21, 1938

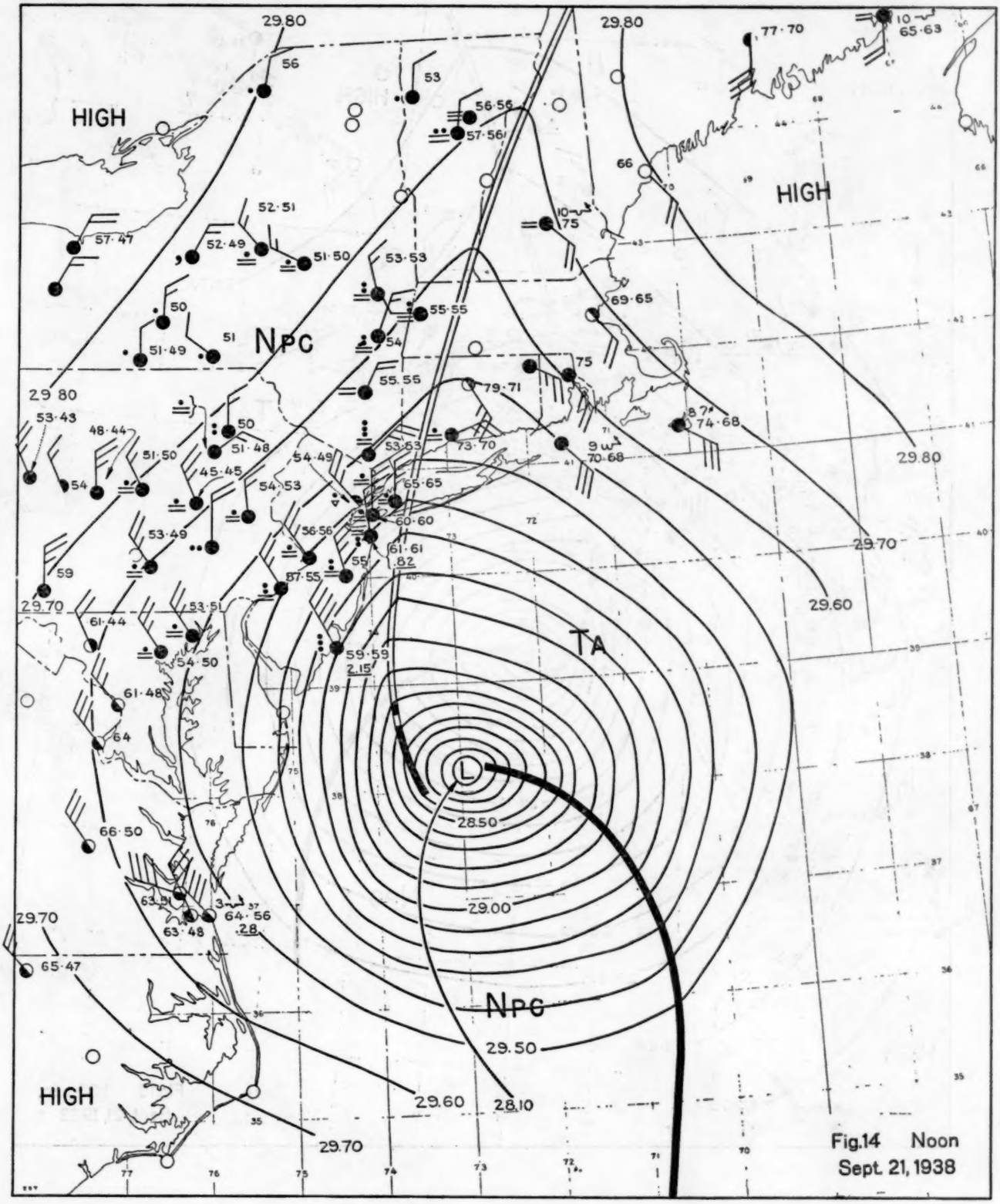

HIGH
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Fig.14 Noon
Sept. 21, 1938

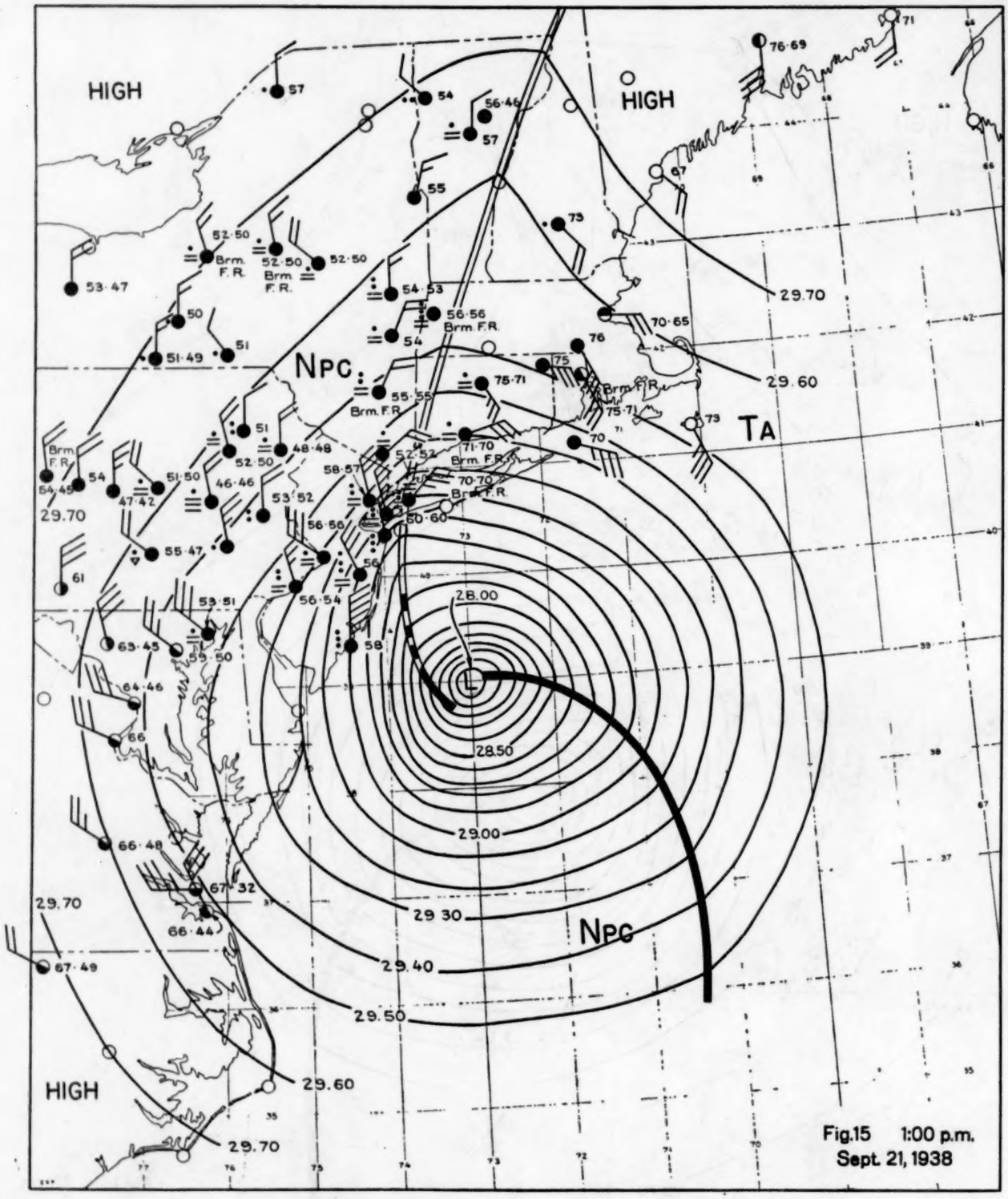

Fig.15 1:00 p.m. Sept. 21, 1938

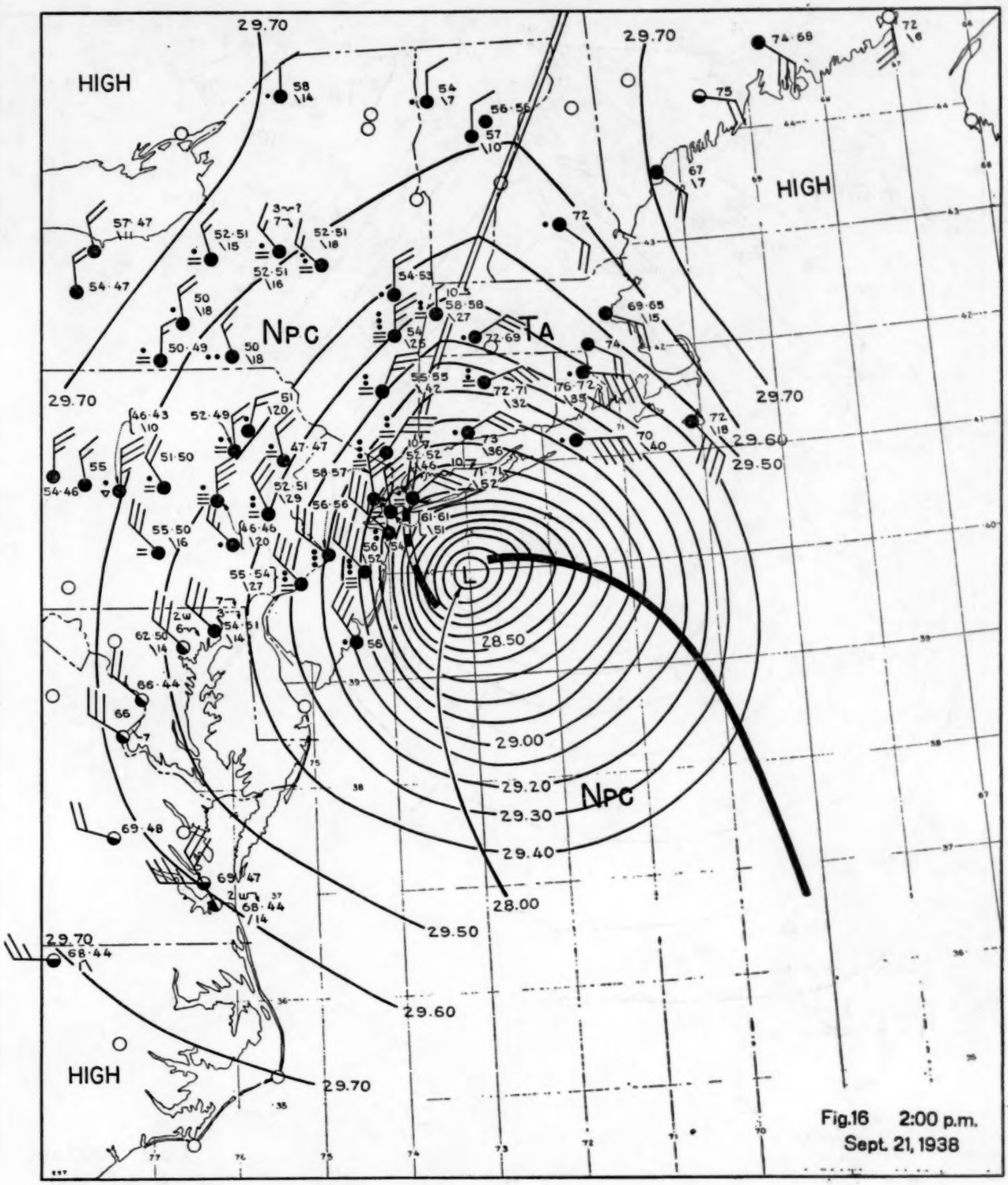

Fig.16 2:00 p.m. Sept. 21, 1938

182360—39—3

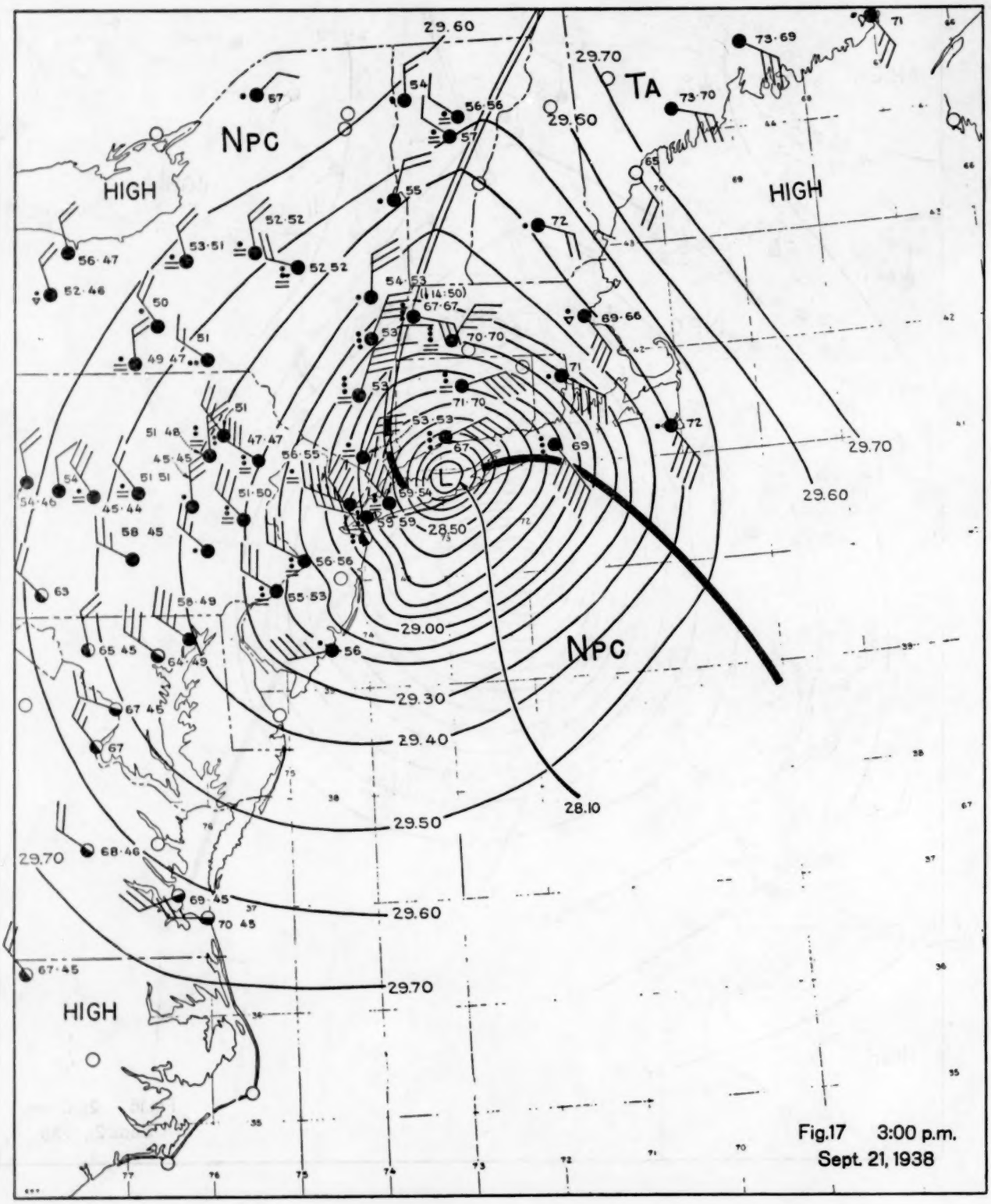
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Fig.17 3:00 p.m.
Sept. 21, 1938

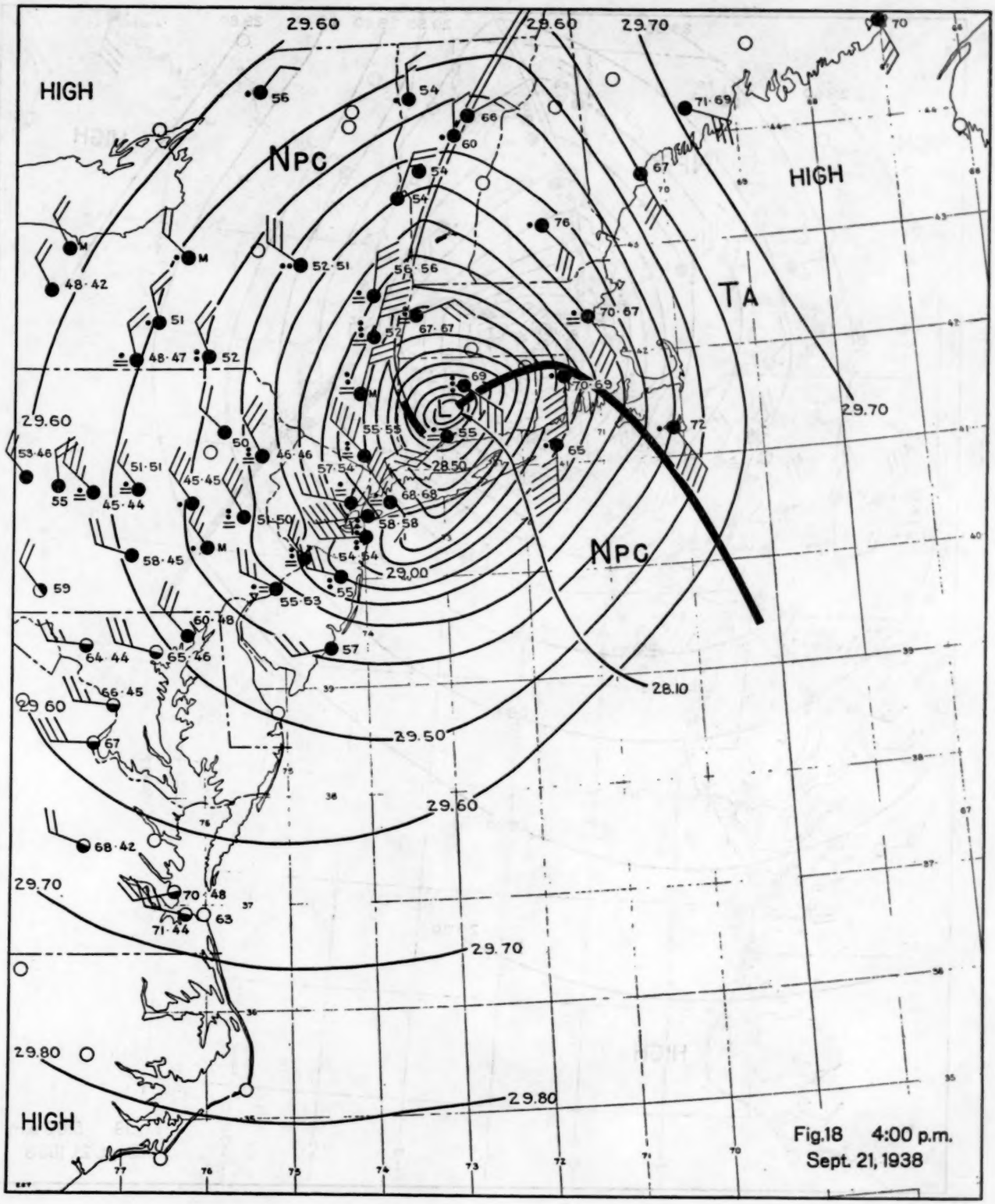
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Fig.18 4:00 p.m.
Sept. 21, 1938

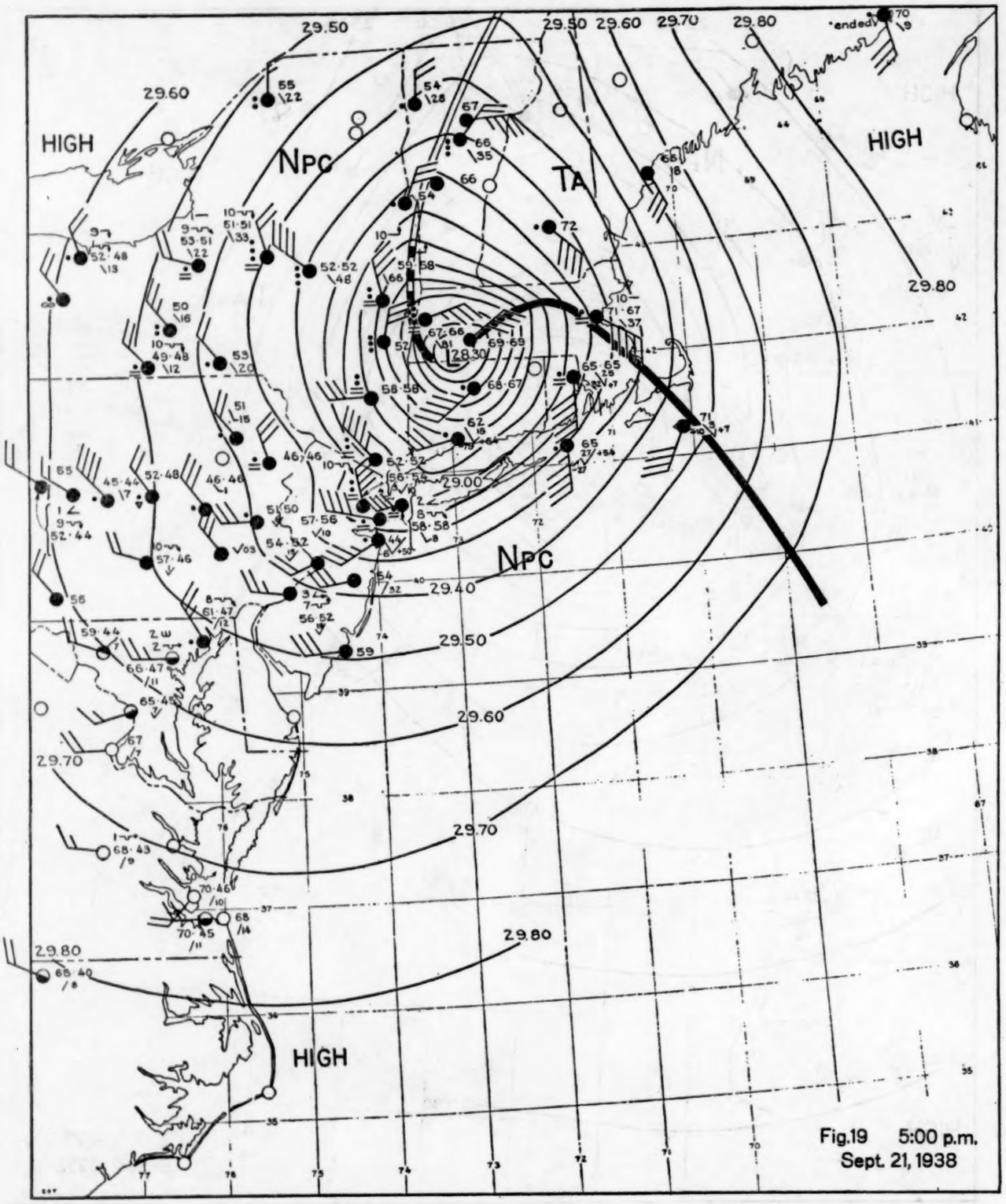

Fig.19 5:00 p.m. Sept. 21, 1938

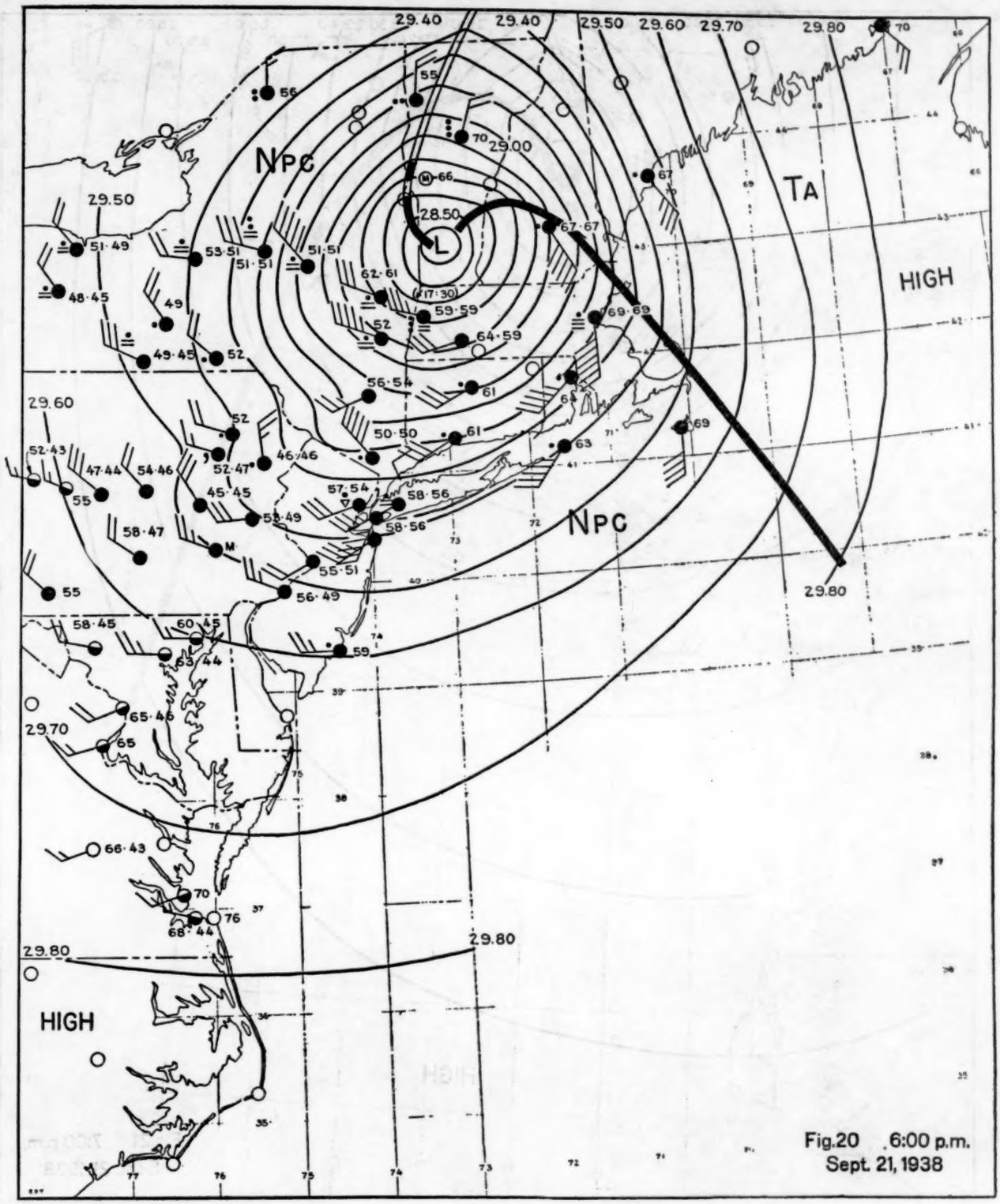

Fig.20 .6:00 p.m.
Sept. 21, 1938

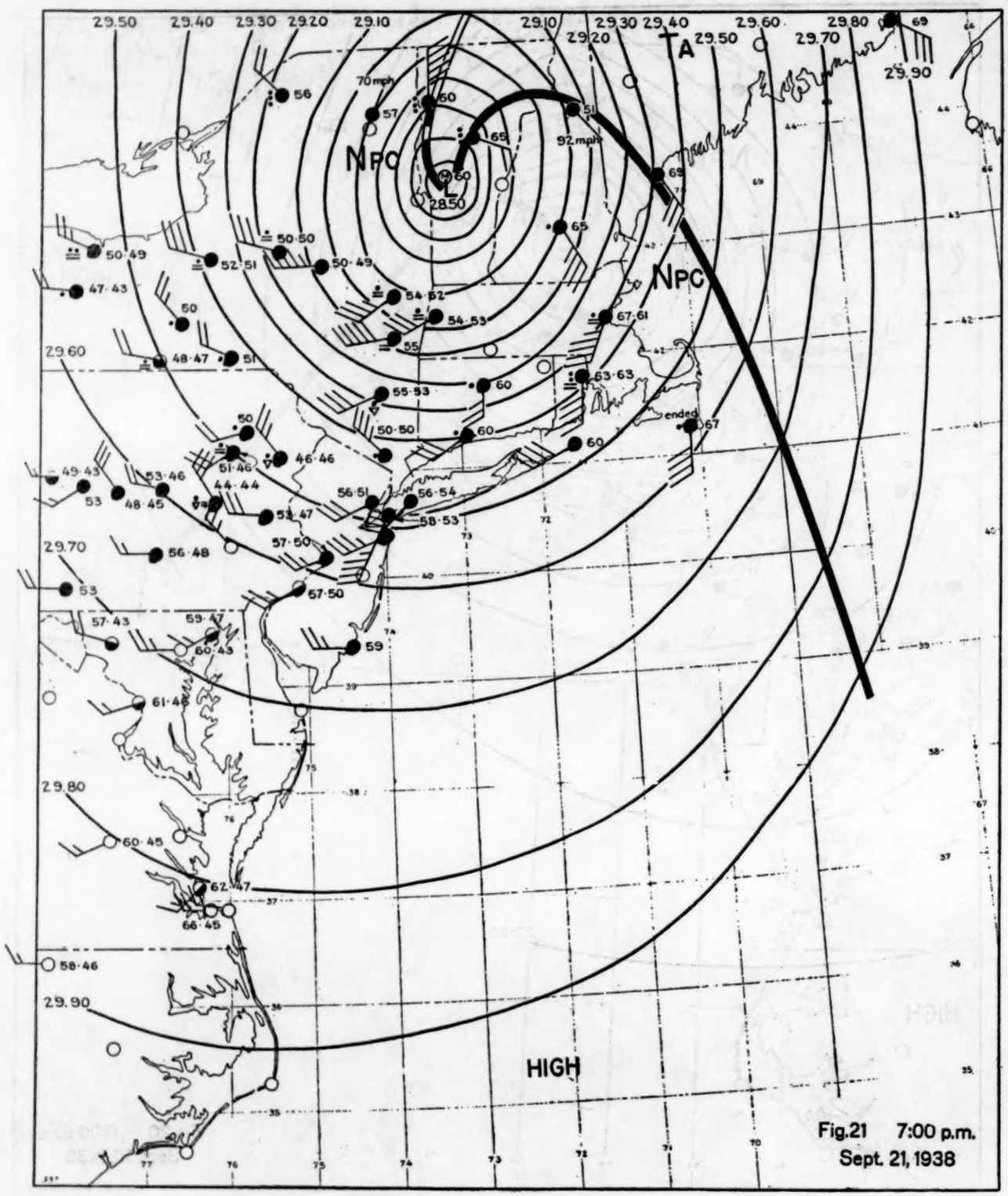

Fig.21 7:00 p.m.
Sept. 21, 1938

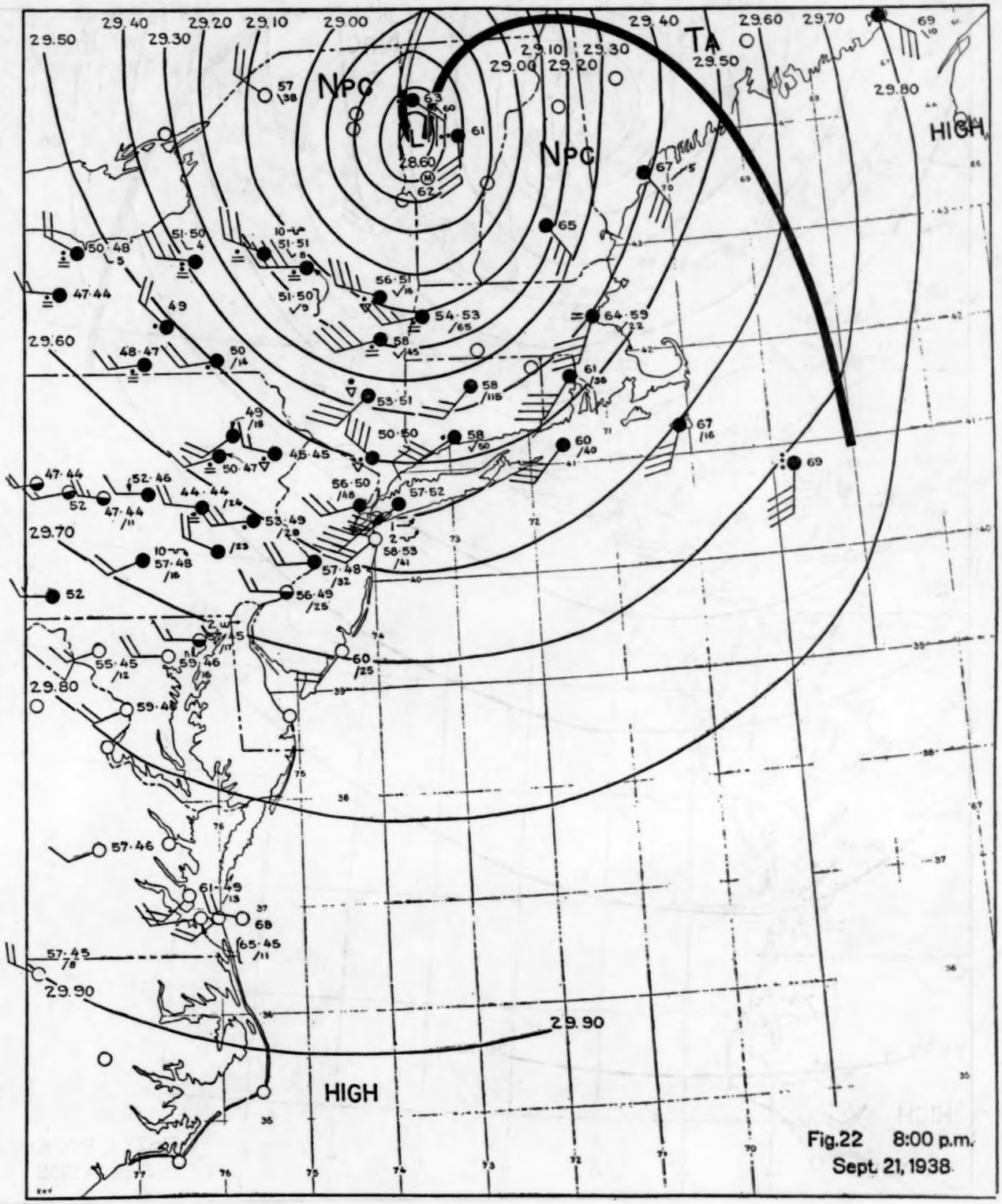

Fig.22 8:00 p.m. Sept. 21, 1938.

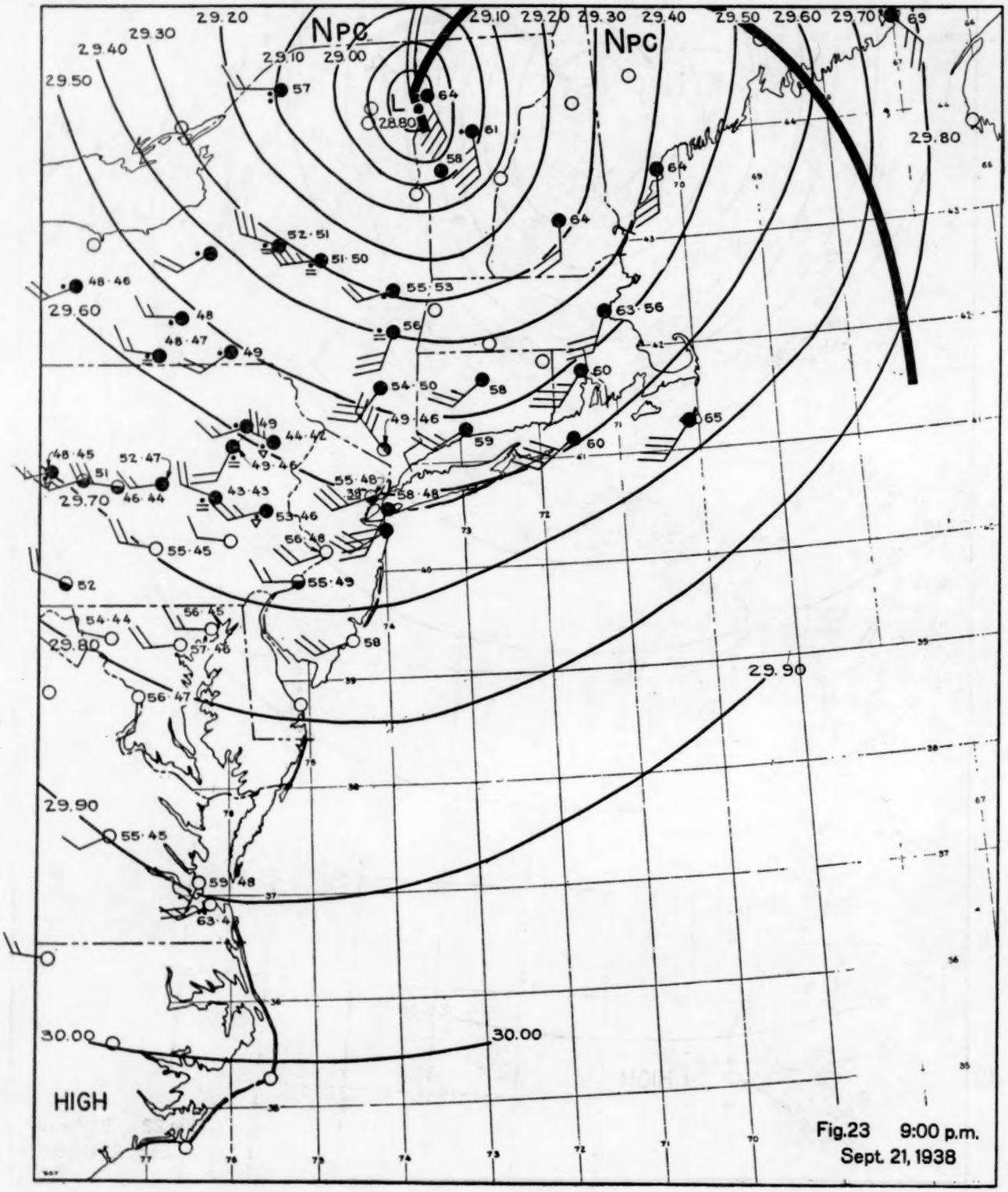
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Fig.23 9:00 p.m.
Sept. 21, 1938

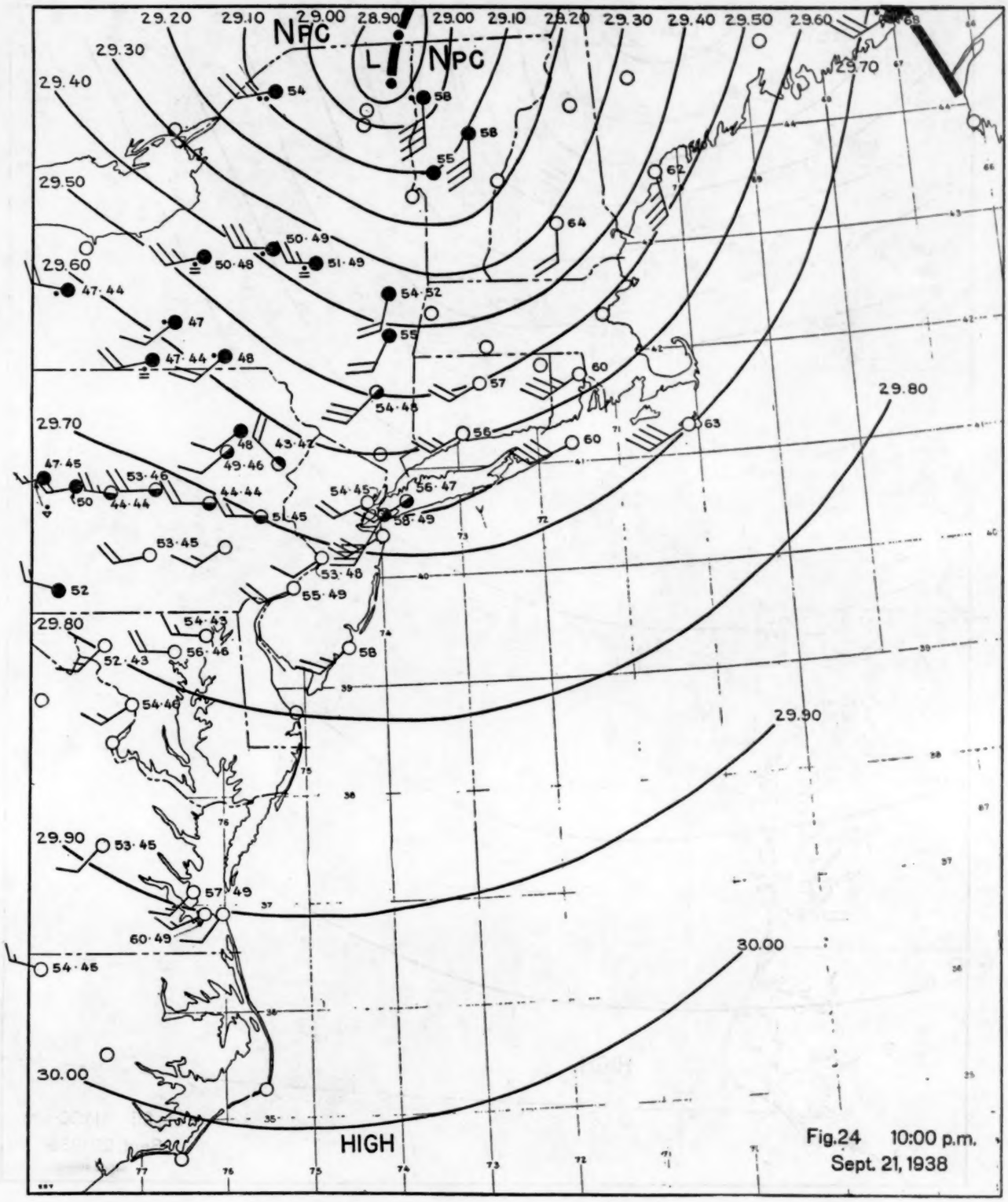


Fig.24 10:00 p.m. Sept. 21, 1938

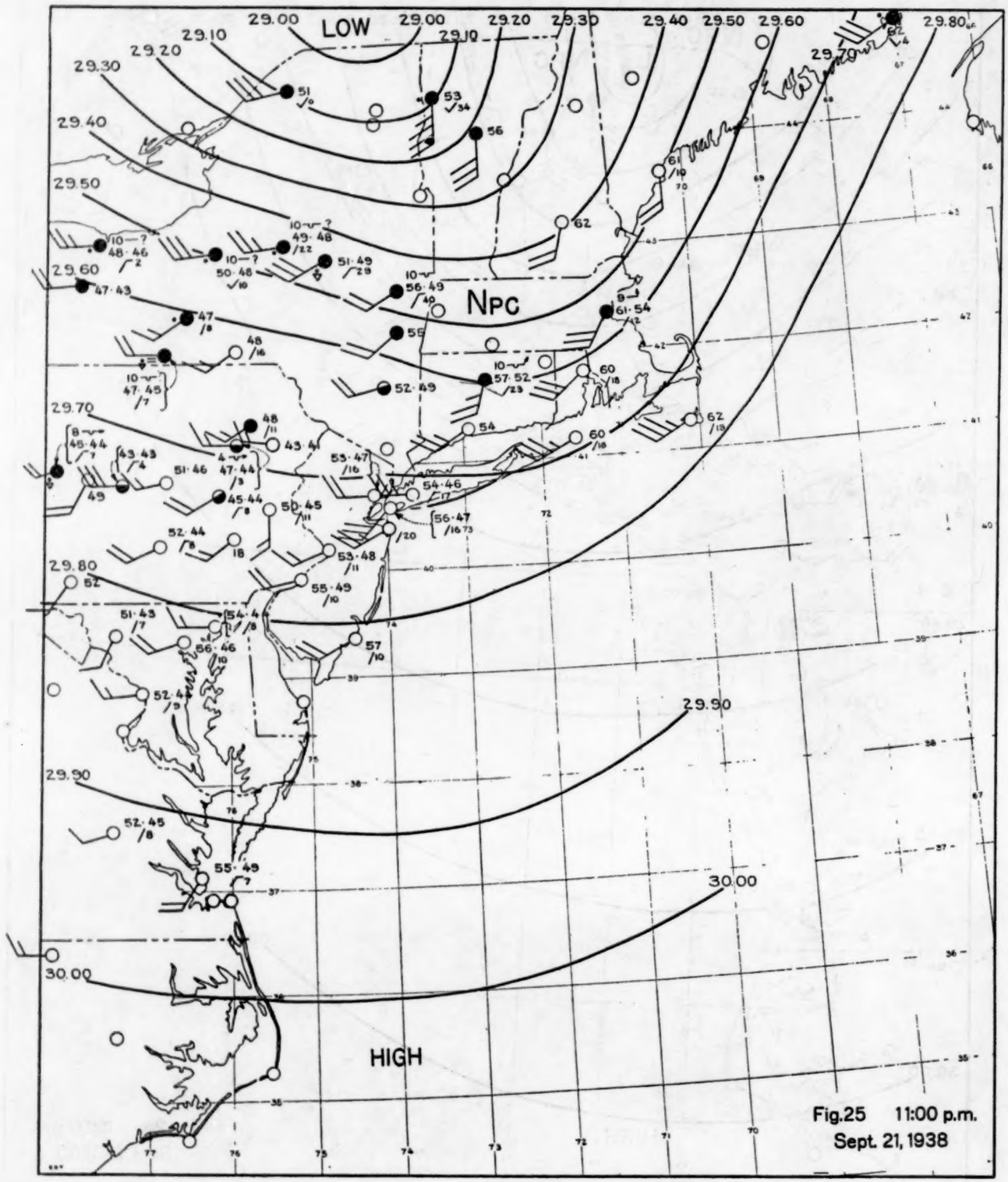


Fig.25 11:00 p.m. Sept. 21, 1938

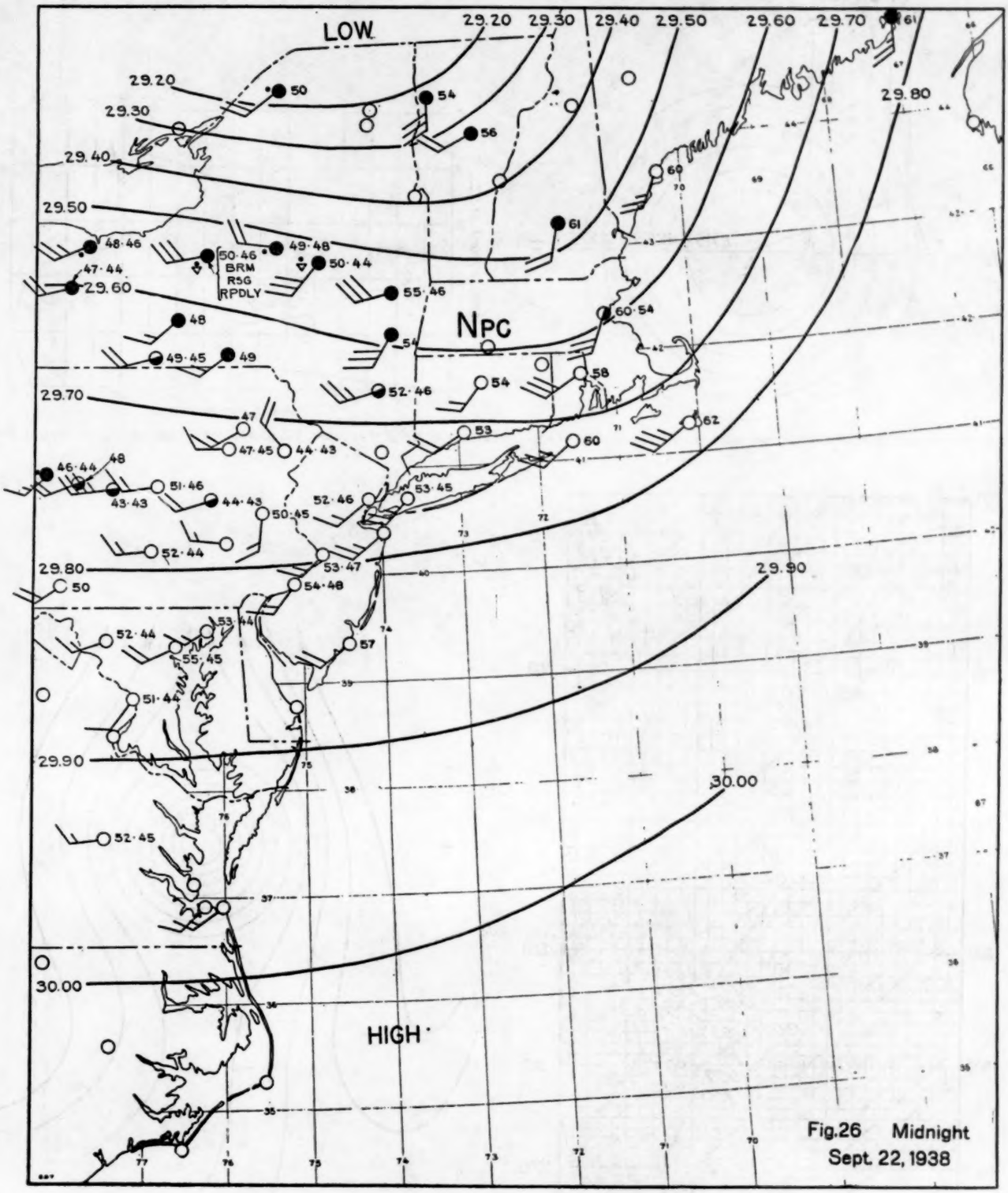


Fig.26 Midnight
Sept. 22, 1938

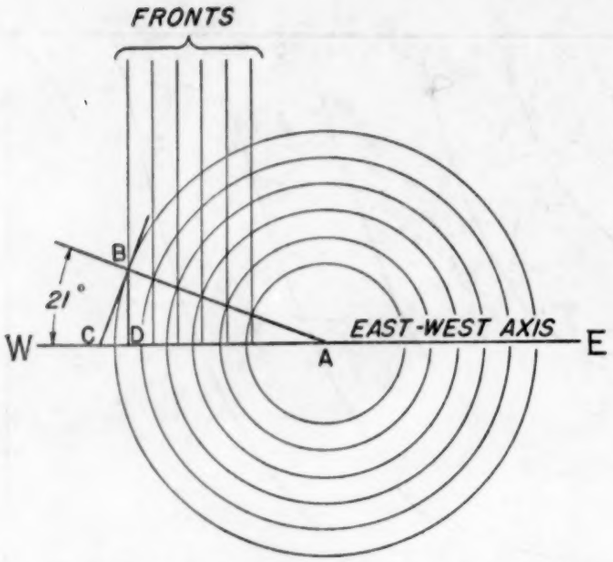


FIGURE 27. Schematic diagram of frontal movement in northwest quadrant of a LOW.

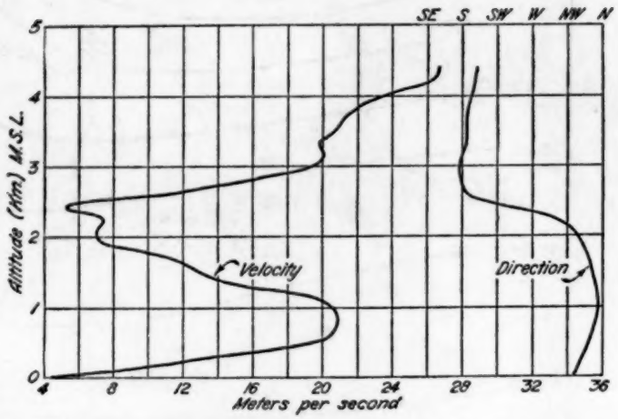


FIGURE 28. Graph of Arlington, Va., pilot balloon observation 7:52 a. m. Sept. 21, 1938.

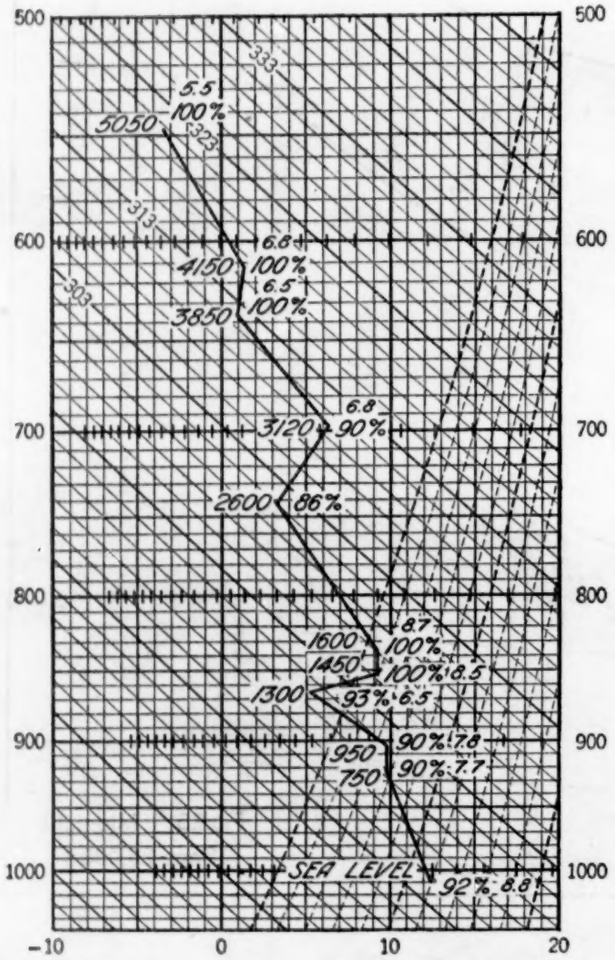


FIGURE 29. Temperature-pressure graph of the Anacostia, D. C., radiosonde observation 4 a. m. Sept. 21, 1938.

FIGURE 30. Possible stream lines at 10,000 feet altitude in the vicinity of the hurricane.

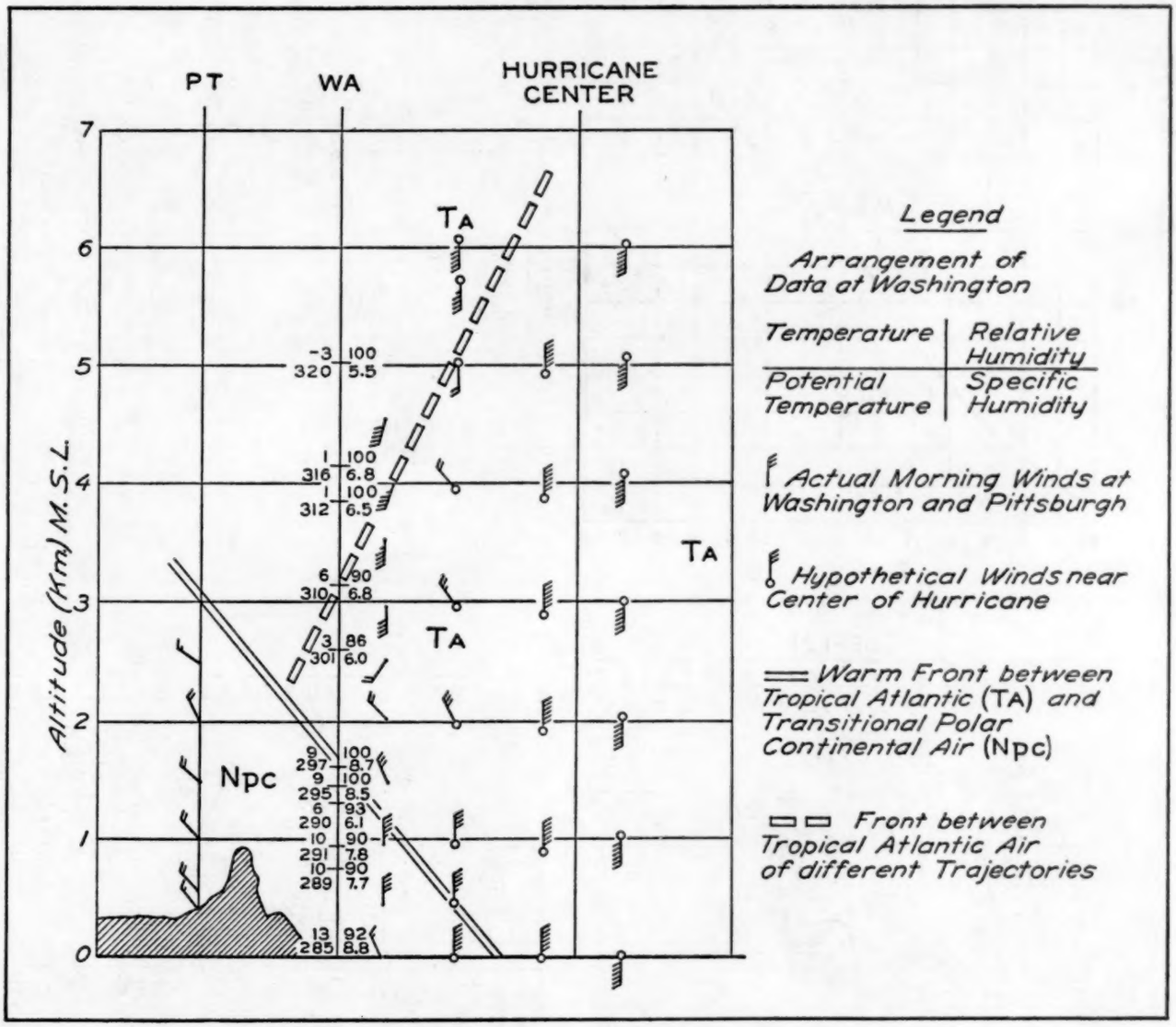


FIGURE 31. Atmospheric cross-section through Pittsburgh, Washington, and the hurricane center Sept. 21, 1938.

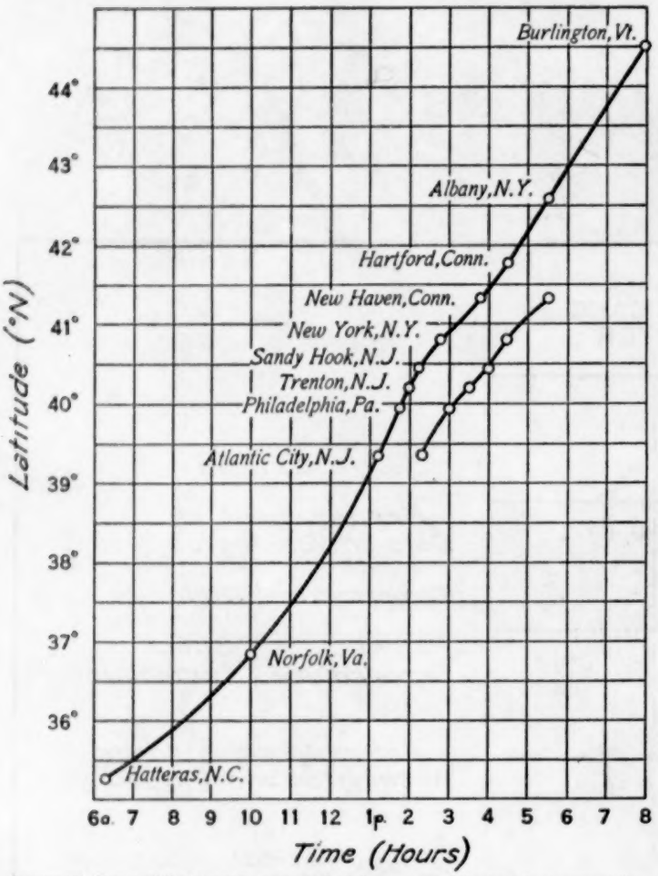


FIGURE 32. Times of the lowest pressure and of the passage of the trough at some of the stations.

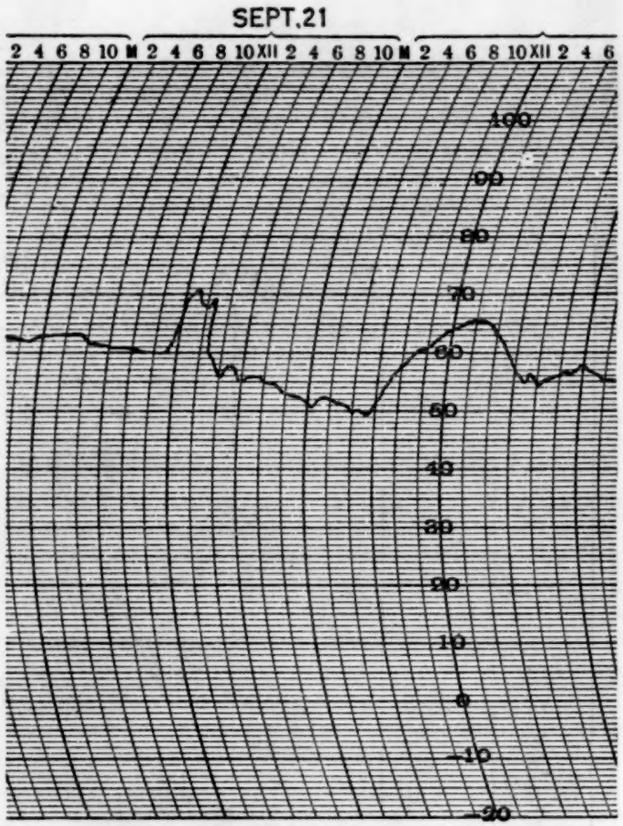


FIGURE 33. Thermograph record from Mitchel Field, N. Y., Sept. 21, 1938.

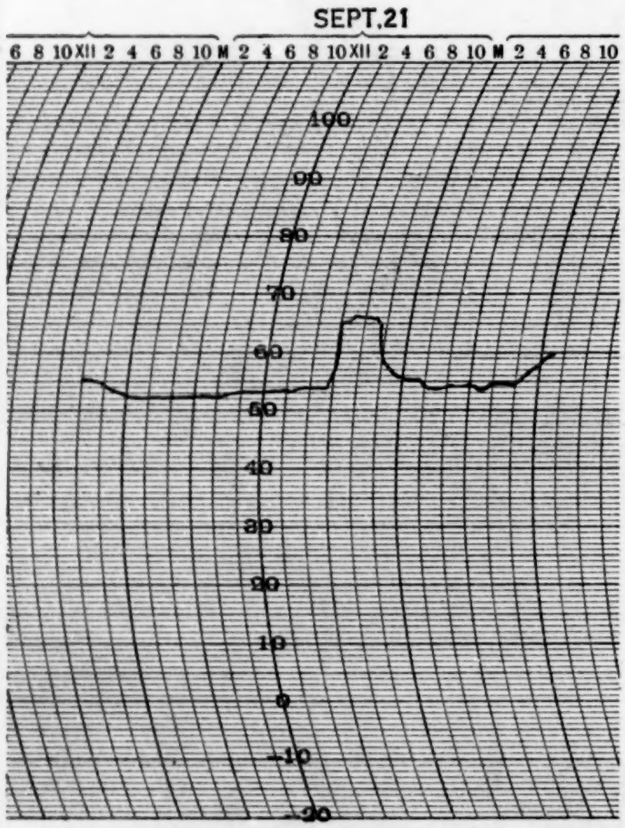


FIGURE 34. Thermograph record from Brandon, Vt., Sept. 21, 1938, through courtesy of Miss Shirley Farr (time is eastern daylight saving).

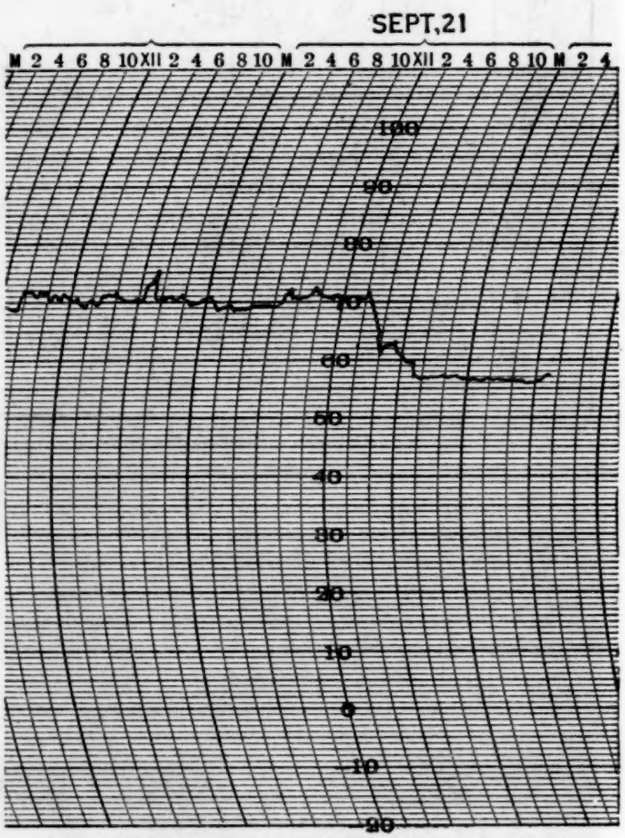


FIGURE 35. Thermograph record from Block Island, R. I., Sept. 21, 1938.

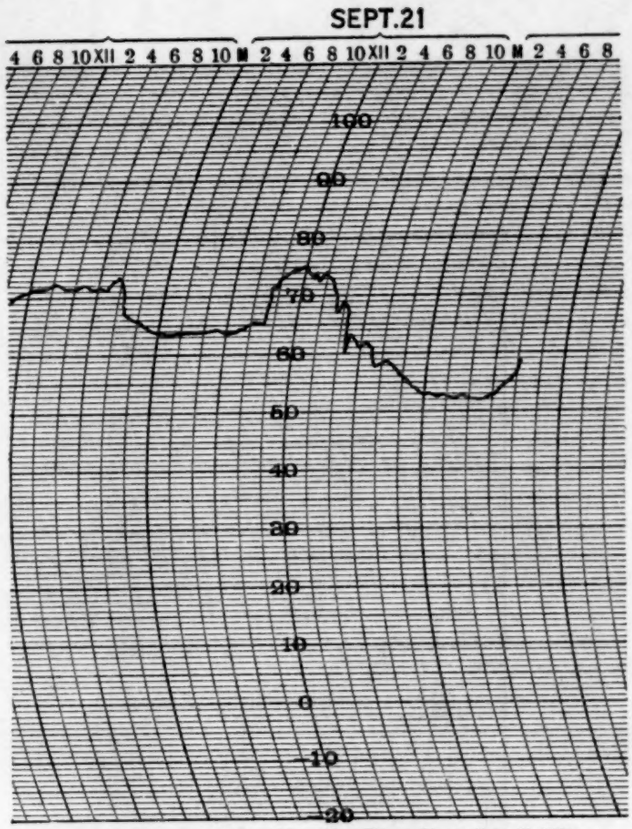


FIGURE 36. Thermograph record from New Haven, Conn., Sept. 21, 1938.

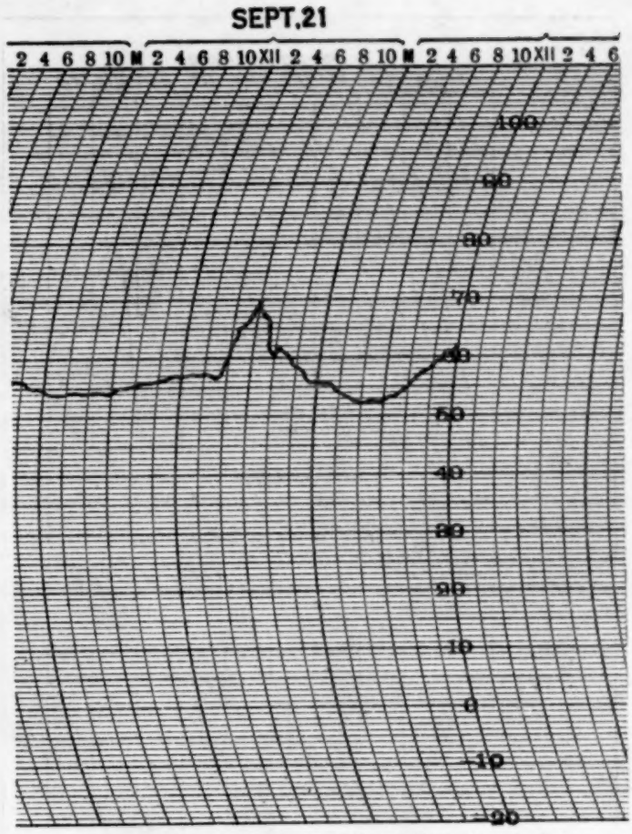


FIGURE 37. Thermograph record from Northfield, Vt., Sept. 21, 1938.

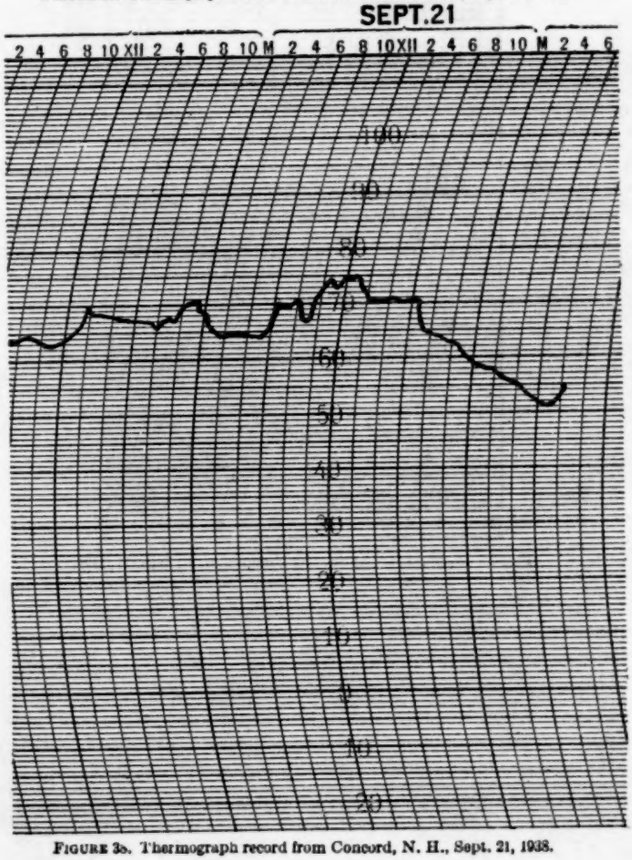


FIGURE 38. Thermograph record from Concord, N. H., Sept. 21, 1938.

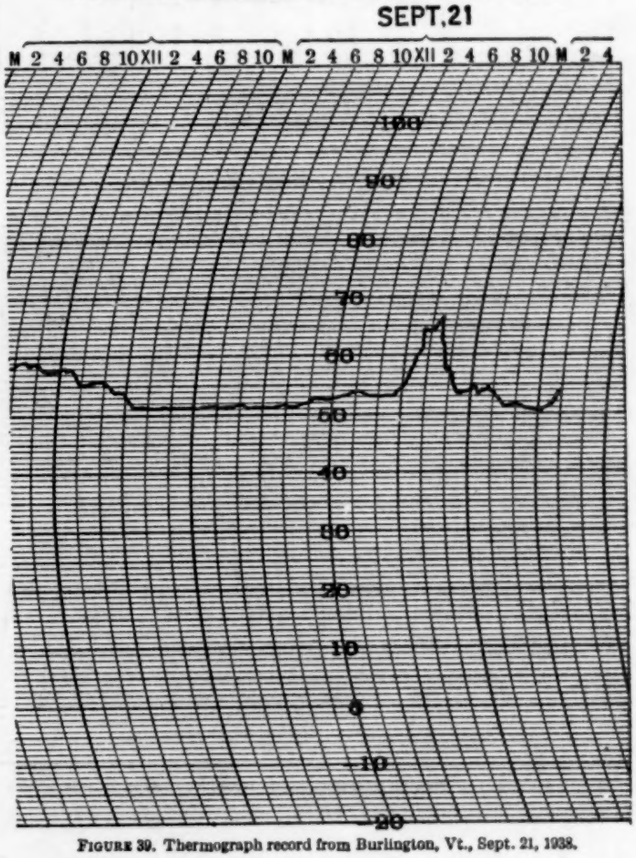


FIGURE 39. Thermograph record from Burlington, Vt., Sept. 21, 1938.

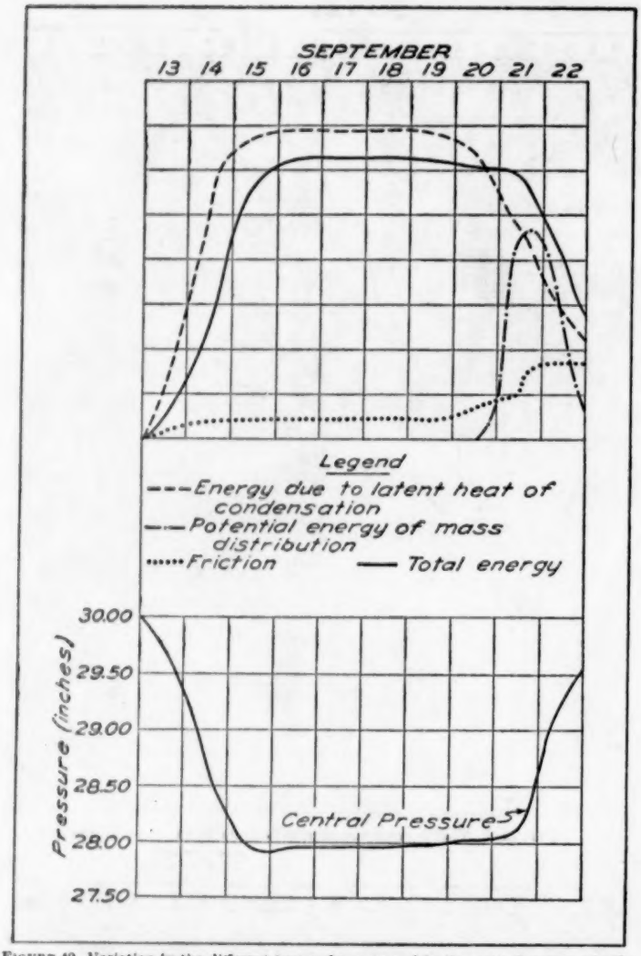


FIGURE 40. Variation in the different types of energy and in the central pressure in the hurricane.

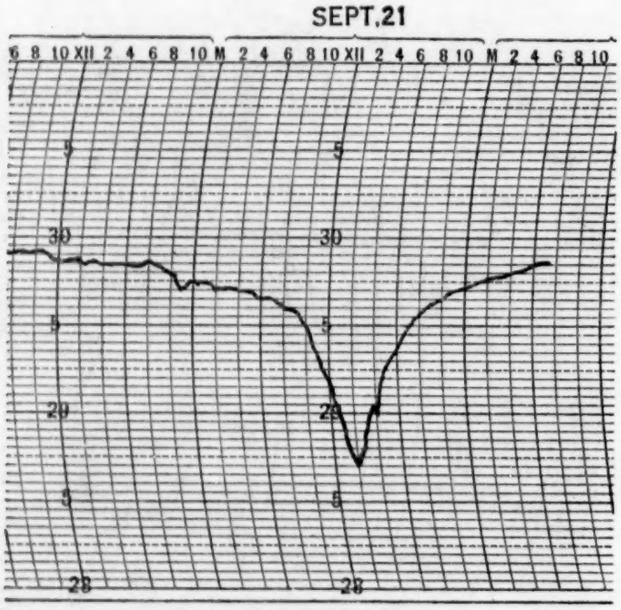


FIGURE 44. Barograph trace from Sandy Hook, N. J., Sept. 21, 1938.

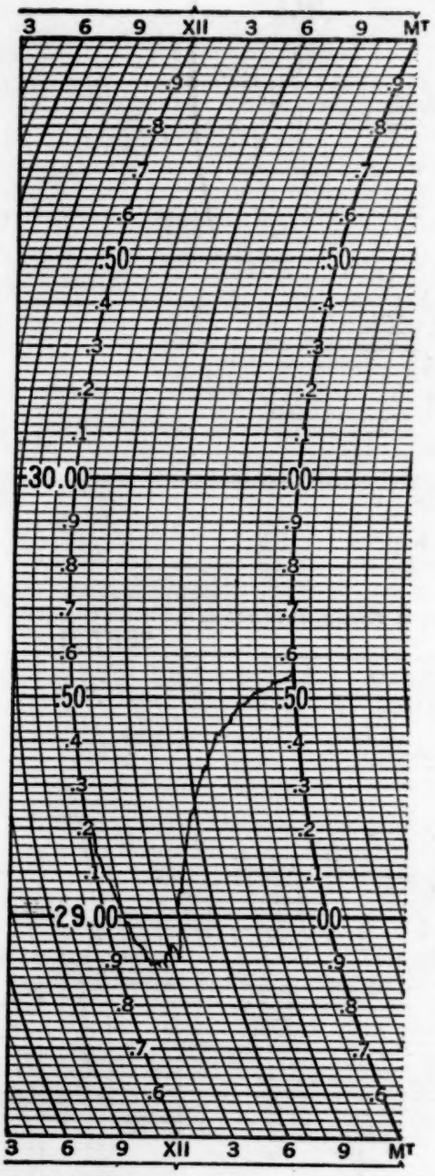


FIGURE 43. Barograph trace from Trenton, N. J., Sept. 21, 1938.

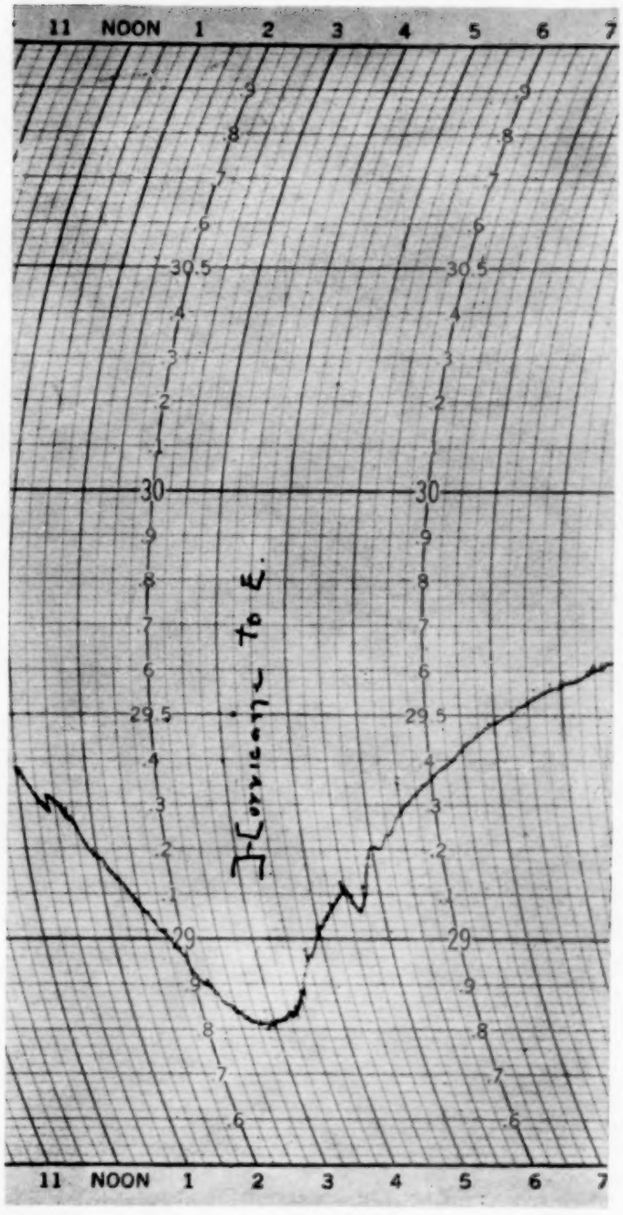


FIGURE 41.—Barograph trace from Newark, N. J., September 21, 1938, through courtesy of Eastern Airlines, Inc.

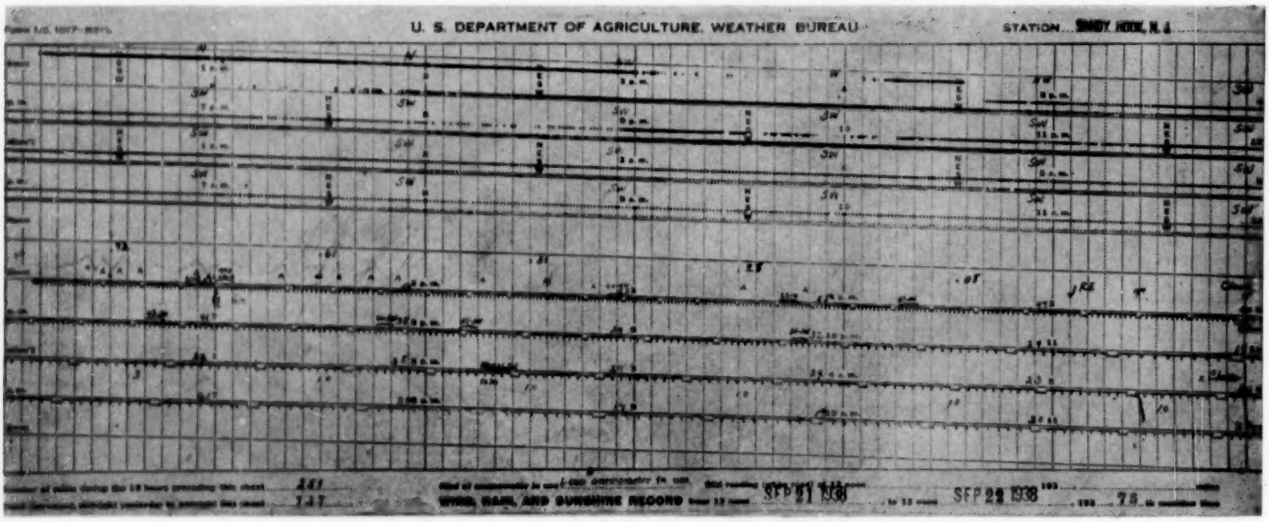


FIGURE 42.—Triple register record from Sandy Hook, N. J., September 21, 1938. The trough passage is indicated by the wind shift at 4 p. m.

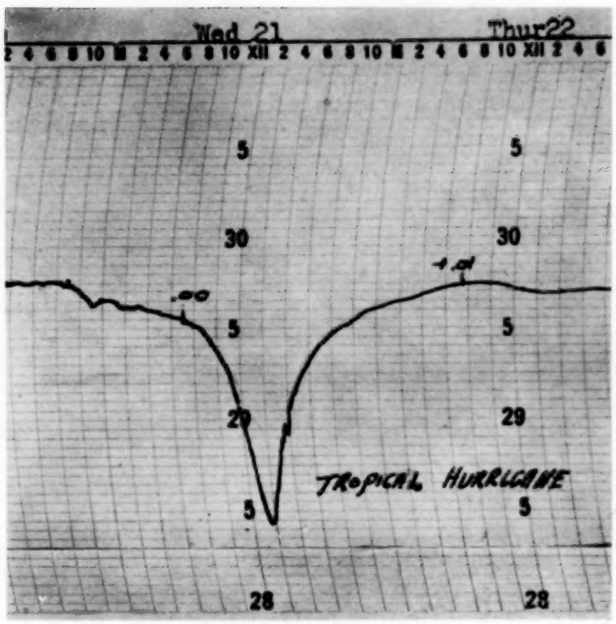


FIGURE 46.—Barograph trace from Mitchel Field, N. Y., September 21, 1938.

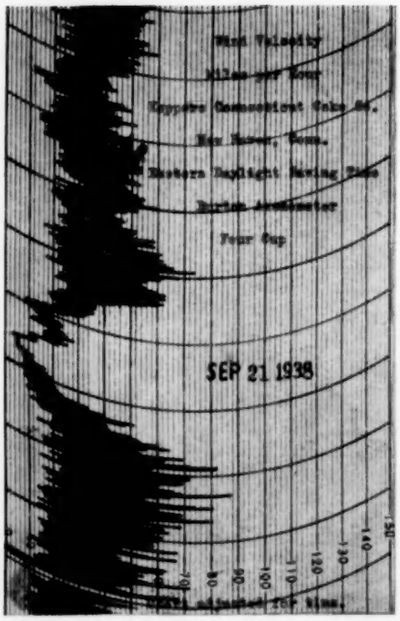


FIGURE 40.—Anemometer record from New Haven, Conn., through courtesy of Koppers Coke Co. (Burton Anemometer, four cup).

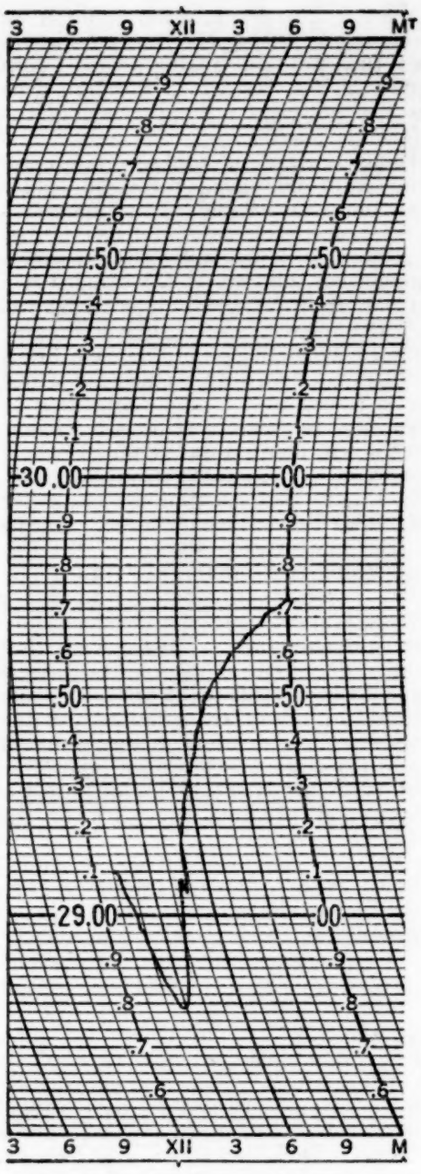


FIGURE 45. Barograph trace from Newark Airport, Newark, N. J., Sept. 21, 1938.

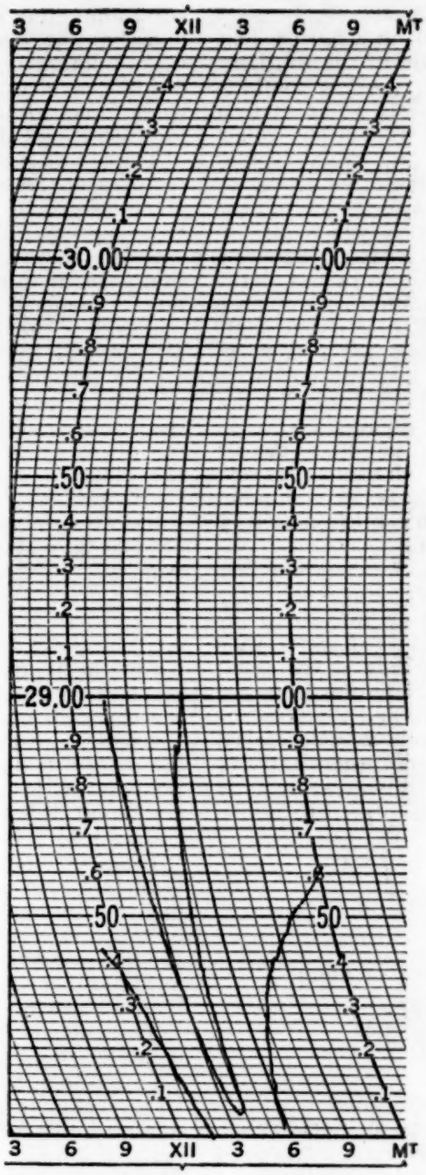


FIGURE 47. Barograph trace from New Haven Airport, New Haven, Conn., Sept. 21, 1938.

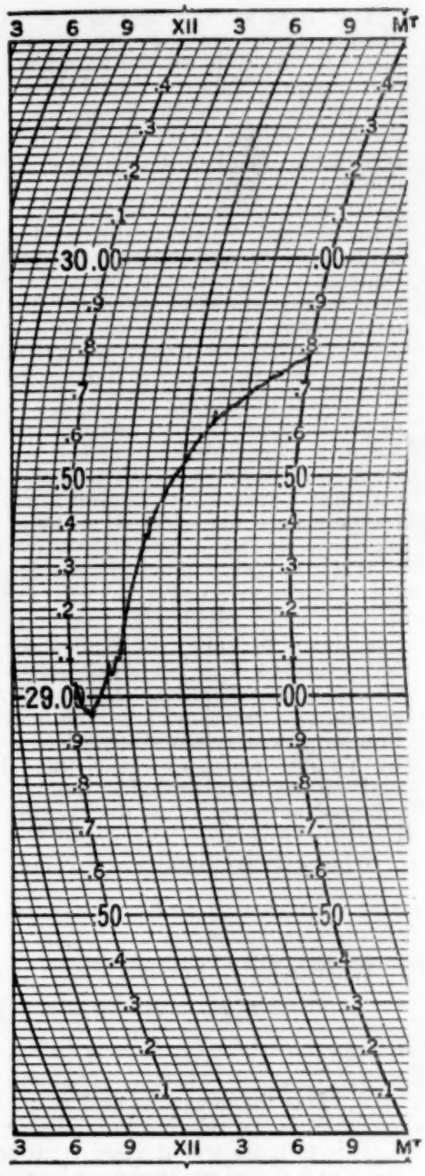


FIGURE 48. Barograph trace from Atlantic City, N. J., Sept. 21, 1938.

182360—39——4

MINIMUM TEMPERATURE FORECASTING IN THE CENTRAL CALIFORNIA CITRUS DISTRICT

By CHARLES C. ALLEN

[Weather Bureau, Pomona, Calif., April 1938]

The citrus-growing region of central California consists of some 42,000 acres, mostly of oranges, in a narrow belt along the foothills of the Sierra Nevada in the southern San Joaquin Valley. Plantings are in the low foothills and on the floor of the valley immediately adjacent to a distance of not more than 5 miles. Elevations range from about 375 feet above sea level on the valley floor to about 1,500 feet in the foothills, with scattered groves at somewhat higher elevations. Over two-thirds of the total acreage is planted to navel oranges, which mature in November and are mostly picked before damaging temperatures ordinarily occur. Valencia oranges, however, and portions of the lemon and grapefruit crops are on the trees throughout the winter; of these about 5,000 acres are located where orchard heaters are needed to protect the fruit against damage by frost. As an aid to growers in protecting their crops the Fruit Frost Service of the Weather Bureau has maintained an organization in the district each winter since 1922–23, the season lasting from November 1 to February 15. Headquarters are centrally located at Lindsay. Forecasts of minimum temperatures at selected stations and other advisory warnings are broadcast nightly by radio.

While Polar Continental air masses make their way into the valley in rare instances, with low temperatures by day as well as by night, the predominant air masses of the San Joaquin Valley in winter are Polar Pacific, with temperatures of 32° or lower occurring only as the result of nocturnal radiation. Inasmuch as radiation from the ground is a function of the temperature and the absolute humidity, a simple mathematical formula was developed by Young [1] which expresses these factors quantitatively and shows the probable minimum temperature. As adapted empirically to the central California citrus district, this formula is as follows:

When relative humidity is below 52 percent:

$$T_m = D - \frac{D-28}{3} - \frac{H-30}{4}.$$

When relative humidity is 52 percent or more:

$$T_m = D - \frac{D-28}{3} - \frac{H-30}{4} + \frac{H-52}{6}$$

where T_m is the expected minimum,

D is the dewpoint at 5 p. m. (local time),

H is the relative humidity at 5 p. m. (local time).

This formula was devised from actual case histories of frost and therefore applies only to average conditions in a particular locality, i. e., the neighborhood of Lindsay, Calif. In 16 years of record the range of dewpoints at Lindsay preceding frost has been from 20° to 52°, frosts most often occurring within the range 30° to 48°, with maximum frequency at 40°. Dewpoints below 30° are infrequent in central California in winter and are significant of unusual conditions, limiting the applicability of the formula, It has not been found practicable to introduce constants into the formula for differing soils, ground moisture, maximum temperature, types of pressure distribution, etc., as these influences are too difficult of mathematical expression. At best the formula indicates the minimum temperature probable under average conditions on clear, quiet nights. Other factors must be weighed according to the judgment and experience of the forecaster, and the formula modified appropriately.

The use of this formula to show the probable minimum temperature resulting from nocturnal radiation under given conditions of air temperature and water-vapor content (note that dewpoint and relative humidity together associate these two factors) is dependent on the assumption that air in contact with the ground thus cooled will remain in place and not drain off down slope under the influence of gravity. Drainage of cooled air would cause replacement by warmer air, so that computations based on the formula would not apply. The place for which minimum temperature forecasts are made according to the formula, therefore, must be carefully selected. Generally speaking, this point will be on a flat plain or where the slope is very gradual. Locations near Lindsay, Calif., are suitable in this respect, so that the main key station for the entire citrus belt is located there. At the Lindsay key station the temperature shown by the formula will approximate the actual minimum within 2° on ideal radiation nights. Forecasts are therefore made for the Lindsay key station, and estimates for other stations are then made according to elevation. The theory is that minimum temperatures on slopes and hillsides are a function of the temperature inversion. Variations from the expected minimum at Lindsay are estimated on the basis of (1) topography; (2) maximum temperature of the preceding day; and (3) atmospheric water vapor (the temperature inversion is obviously a function of both the maximum temperature and absolute humidity of the surface air.)

Inasmuch as few nights in an average winter afford ideal radiation conditions, computing the minimum temperature by means of the hygrometric formula is but the first step in actual forecasting. It is necessary to foresee: (1) regional change of air mass, with resultant effect on local weather; and (2) changes *within* the air mass, such as local fog or cloud.

The topography of the San Joaquin Valley is fundamentally important in comprehending movement of air masses into and out of the region. Shaped like a gigantic U, the valley is bounded on the west by the Coast Range; on the south by the Tehachapi Mountains; and on the east by the Great Western Divide of the Sierra Nevada. This three-sided barrier, in effect one unbroken mountain chain, effectively interferes with change of air mass at low levels. Indeed, it is not uncommon for change in air mass to take place aloft with important effects on frost probability, while surface air remains unchanged. A spell of frost is sometimes brought to an abrupt close by intermediate or high clouds as warm air moves northward over the valley without disturbing the surface strata; or, conversely, frost may follow suddenly when fog is cleared by turbulent mixing due to the same cause. At times new air masses seem to cross the Coast Range laterally and move *over* the valley before change in the surface air has been accomplished. In occasional years Polar Continental air makes its way over the mountains into northern Cali-

[1] Forecasting Minimum Temperatures in Oregon and California. Floyd D. Young, Monthly Weather Review, Supplement 16. Also: A Critique on the Construction and Use of Minimum Temperature Formulas. Eckley S. Ellison. Monthly Weather Review, December 1928.

fornia, thence spreading southward into the San Joaquin Valley to cause abnormally low temperatures. As a rule, however, air masses in the valley are renewed by fresh Polar Pacific air moving into the region through the low passes of the Coast Range in the vicinity of San Francisco Bay. This provides an important element in forecasts for the southern portion of the valley, i. e., change of weather takes place progressively from north to south.

In actual practice, the procedure in forecasting minimum temperatures in the citrus belt is as follows:

1. Analysis of the prevalent surface air mass by means of the hygrometric formula, indicating whether or not frost is probable.
2. Reference to possible changes in the surface air taking place northward and progressing southward, as shown in hourly reports of airways weather stations.
3. Reference to the evening weather map to ascertain if regional change of air mass is likely to occur during the forecast period, either aloft or at the surface, or both.

These steps are in the order of importance in making minimum temperature predictions in the central California citrus district. Inasmuch as air masses change with comparative slowness in the valley, the temperature and dewpoint at 5 p. m. afford the best indications of frost probability during the ensuing night. It is not too much to say that without knowledge of temperature and dewpoint *in the exact locality*, and that simple but useful device, the Young hygrometric formula, accurate quantitative forecasting would be impracticable. Once the local surface conditions have been accurately evaluated, the possibility of changes during the night must be investigated: If no material changes are taking place in the northern end of the valley by 7 p. m., when the forecasts are released, it is unlikely that there will be a change in the citrus belt before morning (exceptions are known, however). The role of the evening weather map of the northeast Pacific area is: (1) To show possible changes of air mass which might not be obvious from conditions in the north end of the valley at 7 p. m.; (2) to furnish clues to changes of or within the air aloft, as upper fronts, intermediate or high clouds, water vapor discontinuities resulting from subsidence, etc.; (3) for making forecasts for more than one night.

It is believed that in the central California citrus district, at least, weather maps cannot be classified as favorable or unfavorable to frost on the basis of barometric distribution alone. Frost has occurred under almost every conceivable type of pressure distribution, and differences in weather accompanying markedly similar pressure types can be extreme. Change in pressure distribution, however, may be associated with changes in air mass, or, in the San Joaquin Valley may act to prevent change. A simple classification of generalized pressure types may therefore be useful. With emphasis on the fact that they are but points of departure for analysis of individual situations, such a classification is herewith presented. All data except isobars are intentionally omitted, for classification being on the basis of barometric pressure, inclusion of air mass data would confuse the issue and make them examples of individual rather than type importance. For example, a weather map showing a Great Basin anticyclone might include anything from fine, warm weather to cool, foggy situations, or severe frosts.

Employing a nomenclature from the geographical center of pressure at the stage of development when frost is most probable in the citrus belt, these are called: Type I, Great Basin HIGH, Type II. California HIGH, Type III. Plateau LOW.

Type I, *Great Basin* HIGH.—See maps for December 25, 1929, to December 27, 1929, inclusive. Following a more or less rapid rise in pressure off the Washington-Oregon coast, there is also a rapid increase over the Great Basin area within 12 to 24 hours. The fully developed Great Basin anticyclone is connected with the semipermanent Pacific high pressure by a great, curved ridge. Pressure over California is decidedly lower. With this enormous mass of fresh Polar Pacific air to the west, north, and northeast, movement of new air masses into the San Joaquin Valley cannot take place, and the weather will remain more or less as at the beginning of the regime, or will be modified but slowly. The Great Basin anticyclone is also important because of its persistence, as, aided by nocturnal radiation, pressure at the center increases slowly and great stability is achieved. The weather of the San Joaquin Valley may show extreme variations under the dominance of this type, depending on the properties of the original air mass. If the valley has been filled previously with warm, dry air as often happens in November, the weather will continue fine. Quite warm days may be followed by frosty mornings, and a daily range of over 40° is not uncommon. If, on the other hand, cool, moist air is in the valley at the beginning of the cycle, persistent fogs are probable, typical of December weather. As subsidence within the anticyclone takes place, the cool, moist air resting on the ground is separated from the warmer and drier air aloft by an effective discontinuity. If the surface air is relatively dry and cool, however, no discontinuity becomes established to produce fogs, and a spell of frosty nights will follow, lasting sometimes 2 weeks or more without a break. Decadence of the Great Basin anticyclone is usually preceded by withdrawal of the Pacific center further offshore together with a pronounced 24-hour fall in pressure over the continent. Breakup is rapid in the final stages, and the map may change to a variant of Type III abruptly.

Type II. *California* HIGH.—See maps for January 19–21, 1934, inclusive. With the center of the Pacific HIGH off the California coast, weak low-pressure systems along coast and extending into California-Nevada are often followed by a rapid rise in pressure directly over California; the center of highest pressure may be in the San Joaquin Valley or in Nevada. This type is fairly frequent in winter, but is not persistent like Type I. Temperatures are not abnormally low as they may be with either Type I or Type III. Ground fogs may occur, but are not usual. Minimum temperature forecasting may be very difficult at the beginning of this type owing to the rapidity with which the new air mass moves into the valley. It is probable that air-mass change takes place aloft by lateral transport over the Coast Range before a surface change is effected by movement southward into the valley from the San Francisco Bay region.

Type III. *Plateau* LOW.—See maps for December 6–12, 1932, inclusive; and for January 4–8, 1937, inclusive. While this type is common in winter, it is associated with frost less frequently than Types I and II: nocturnal cloudiness or light winds so often persist after passage of the storm that the weather map has changed to Type I or II before the first night favorable to frost. Yet, in the final analysis it is in some ways the most important of the three types in that in may be attended by temperatures which are nothing less than catastrophic to citrus growers. Appearing as a small LOW over the Pacific Northwest, movement southeastward is very rapid, and maximum development of this type takes place when the

center has reached the Colorado Plateau. Most of the annual rainfall, all of the rare and scant snowfalls on the valley floor, and the historic "freezes" or cold waves occur with this type, hence these storms demand careful scrutiny. Relatively low temperatures and evening dewpoints near or below 30° behind the cold front usually mean abnormally cold weather in the citrus belt within 24 hours, with little or no temperature inversion.

Even when the regional air mass is not expected to change, certain modifications may take place which will have important local effects on frost probability. Depending largely on the water-vapor content of the surface air in conjunction with anticyclonic subsidence, the most distinctive development within the air mass is radiation or "high inversion" fog (or stratus cloud). Varying in height above ground from one or two hundred to two or three thousand feet, this fog may last from one night to several weeks, and because of its obvious effect on ground cooling almost insuperable difficulties in minimum temperature forecasting are connected with its initial appearance, extent, and final clearing. The stages of a typical fog regime in the citrus belt are summarized briefly: Forming first in patches at elevations of 50 to 100 feet above ground, the fog soon reaches the ground and becomes dense over a wide area; it is not usually seen in the foothills until one or more nights after its first appearance on the valley floor. Following the first night of fog, clearing takes place in the forenoon over the citrus belt, although fog may remain all day far out in the main valley. When the foothill area is covered during the night, fog will persist most of the next day on the valley floor as "high fog," slowly thinning (evaporating) near the ground. During the ensuing night the process will be repeated, and thereafter the fog will cover the valley floor and more or less of the foothill area for days, even weeks, without a break. The "high fog" of the day lowers to the ground at night, and a familiar development is increasing wetness until trees are dripping and water stands on the ground as after a light rain. After a day or night of such wet fog the horizontal visibility abruptly and remarkably improves although the "high fog" (stratus cloud sheet) remains unbroken. This development is not necessarily a prelude to break-up of the fog.

Clearing of the fog may come suddenly and over the entire region, either by day or by night. More often, however, general clearing is preceded by intermittent clearing *at night* at the limiting elevation of the fog in the foothills. Obviously, intermittent clearing during the day may be due to insolation without a significant change in the general meteorological situation. The end of the regime is also preceded at times by pronounced thinning of the stratus cloud at night, so that the moon's disk may be visible; if stars can be seen the break-up is assured. Falling dewpoints at valley stations, day temperatures remaining the same, are often noted as a prelude to clearing. Final clearing most often begins in the southern end of the valley, but can be so rapid as/to seem otherwise unless frequent reports are available from the whole region. An exception to this rule occurs when a fresh, relatively dry air mass moves into the valley from the northward, evaporating the fog by mechanical mixing.

Fog in the citrus belt is preceded by evening dewpoints of 38° or higher at Lindsay: out of 43 case histories of fog regimes, extending over 6 winters, only once did fog follow a 5 p. m. dewpoint of less than 39°. In 28 of the 43 cases the initial appearance of fog was preceded by dewpoints of 45° to 51°, from which it may be deduced that fog becomes increasingly probable as dewpoints are above 38°. Day temperatures are not a good indication of fog probability: maximum temperatures immediately preceding are usually well below 60°, but fog has been known to follow a maximum temperature at Lindsay of 71° (dewpoint 40°).

While the fog regime is becoming established barometric pressure is rising after a period of cyclonic activity. Center of highest pressure may be in the valley itself, but in the greater number of times by far the center is over the Great Basin. Thereafter the fog regime continues as the Great Basin anticyclone is persistent. This dependence of fog on the Great Basin anticyclone has been observed so many times as to be axiomatic. During early stages of the regime temperatures at mountain stations begin to rise and dewpoints to fall; fine weather continues throughout the cycle. Decadence of the anticyclone signals the end of the fog regime; the process is hastened in proportion to the rapidity of the pressure decline along the north Pacific coast. As temperatures at mountain stations begin to fall and dewpoints to rise, while at the same time winds shift from northeast and east to southerly, fog clears rapidly in the valley.

Although little is known of the vertical structure of valley air masses aside from inferences drawn from mountain station reports, it seems reasonable and logical to attribute the persistent winter fogs of the region to radiational cooling from a humidity discontinuity at varying levels above the ground.[1] In agreement with this assumption, fog is not forecast in the citrus belt until it appears that a discontinuity exists or will be established during the forecast period; and final clearing is expected only when it is believed that the discontinuity will be destroyed.

Since fog is so common in the San Joaquin Valley in winter it is not strange that minimum temperature forecasting in that region resolves itself much of the time into a problem of forecasting fog—the extent, vertical as well as horizontal, and time of beginning and ending *to the very hour*. The horizontal is dependent on the vertical distribution: With little or no air movement in the valley at night, fog does not move or extend from the valley floor to the foothills in a literal sense. Since the upper limit of fog will be nearly the same as the top of the cool, moist surface stratum, the depth of this stratum must first be estimated, and the extent of the fog in the foothills can then be allowed for. Unfortunately, there is no way at present of measuring the depth of the surface stratum with accuracy, since no observations are made of temperatures and humidity aloft over the valley. Observations of the vertical structure of the air are made in the San Francisco Bay region and in southern California, but their applicability to air masses in the valley is questionable, especially at moderate elevations. Nor are observations from foothill stations (temperature-humidity) of much value, since they are affected by ground exposure and are not representative of free-air conditions. In practice, therefore, the height of the discontinuity level is estimated by the distribution of minimum temperatures over the valley floor and adjacent foothills on the general theory that maximum cooling will take place near the discontinuity. Ordinarily, this level seems to be 1,000 feet or more above the valley floor, so that fog forming at this elevation will cover most of the citrus belt. Cases are on record, however, when severely damaging temperatures have occurred in the foothill citrus areas while the valley floor was blanketed under dense fog. It is supposed

[1] For discussion of the physical basis of this assumption, see the following literature: On the Causes and Forecasting of California Fog, Sverre Petterssen, Journal Aero. Sciences, July 1926. Characteristic Weather Phenomena of California, H. R. Byers, ch. II, A Winter Fog in the Interior, by W. M. Lockhart. Fog and Haze: Their Causes, Distribution, and Forecasting, H. C. Willett, Monthly Weather Review, November 1928.

that in such cases the discontinuity level is very low, within a few hundred feet of the valley floor. Inasmuch as temperatures have been observed to fall steadily throughout the night when the sky was clear at moderate elevations in the foothills, it is considered that falling temperatures under dense fog indicate a low discontinuity level.

The question might well be asked why fog is first seen at lowest elevations in the valley, to appear hours or nights later in the foothills. Actually, fog would first form at the condensation level, which under certain conditions might be below the elevation of the foothill stations. Also, it is possible that stratification of the air may be exceedingly complex at times, with more than one discontinuity. Furthermore, in the early stages of a fog regime, the difference in water-vapor content between the surface stratum and warmer air above may not allow of sufficient cooling to produce fog throughout the entire mass. As evaporation from the soil increases the moisture content of the surface air, while anticyclonic subsidence sharpens the discontinuity, cooling would later be sufficient to cause fog throughout the entire layer.

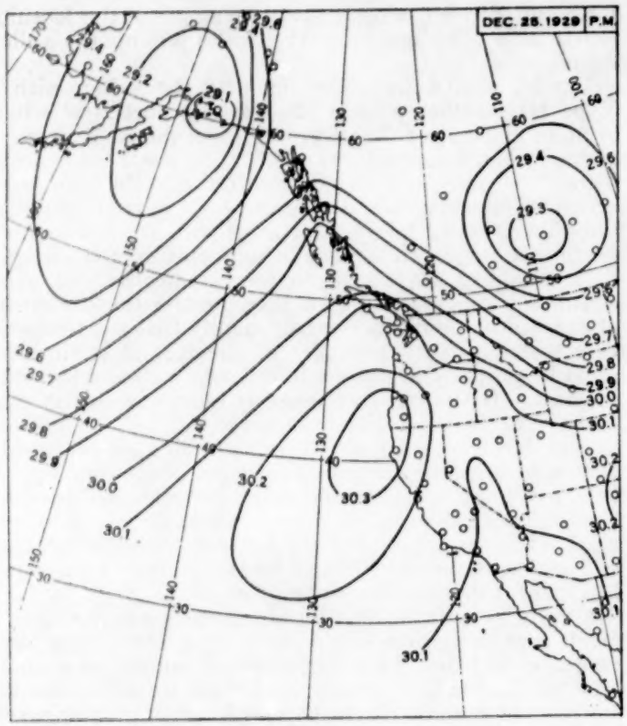
Timing of fog is also essential to minimum temperature forecasting, as the difference of even one hour in appearance or clearing of fog may mean a difference of several degrees in the minimum temperature. In fact, timing of fog is probably the greatest single difficulty in forecasting minimum temperatures in the San Joaquin Valley in winter. For example: From the hygrometric formula a temperature of 26° may be expected if the sky remains clear all night, while at the same time there are indications of fog. If the fog forms early in the night the temperature may not go below 32°; on the other hand delay in appearance of fog until late in the night may allow the temperature to fall to a degree dangerous to crops. Conversely, a few hours difference in the time of clearing of fog may mean the difference between safe and damaging temperatures. In practice, first appearance of fog (almost invariably at night) is timed by general considerations of water vapor content, horizontal visibility at 7 p. m. at valley stations, and previous history of fog in the prevalent air mass. Timing of clearing at night—daytime clearing obviously is not important to the problem in hand—is based on general considerations as to the rapidity of change of air mass, rate of increase in turbulence aloft, and frequent observations at the highest foothill stations, where clearing will usually begin hours before final clearing over the entire district. In this respect it is important to distinguish between the intermittent clearing in the foothills which precedes the break-up of the fog, and the irregular clearing which may be only a function of the height of the fog, i. e., clearing at the top level of the fog due to local turbulence in the foothill region.

Owing to the topography of the valley, wind is not an important consideration in winter, for when frost is probable the weather has become settled and quiet nights are the rule. When the dewpoint is relatively low for the valley, i. e., below 35°, ground cooling is so rapid that the resultant air drainage down the slopes of the foothills is felt as a light breeze several miles out on the valley floor.

Rarely, a cold front moving into the valley with a Type III weather map is attended by northwest winds at night and a clear sky; if properties of the fresh air mass are suitable, temperatures of 32° or lower will occur before sunrise, with wind continuing. On one such occasion, following rain during the early part of the night the sky cleared rapidly, and even with fresh to strong northwest winds all night the temperature fell steadily to a minimum of 26° at sunrise. Indications of wind continuing during the night, therefore, as the sky clears after a storm, do not necessarily signify that the temperature will not fall: Properties of the incoming air mass must be properly evaluated in order to make an accurate forecast. If the fresh air mass is relatively dry it conserves but little of the heat given off by the ground during the night; and since the regional air mass previously heated by insulation has been removed, there is no opportunity for the usual temperature inversion to develop. Consequently there is no warmer air to be mixed by the wind with the air cooled by contact with the ground, and surface temperatures will be the same as on a windless night, other conditions being equal.

Conclusion.—It is a matter of experience that within a given area such as a single citrus grove minimum temperatures will show local variations of one degree or more on even ideal radiation nights. Erratic air drift, unequal amounts of radiation from various kinds of ground covering, and other vague, complex, and perhaps contradictory influences may operate to bring about differing minima within such short distances that it is a practical impossibility to estimate the net effect within the rather small limits of one degree on the Fahrenheit scale. It seems a wholly reasonable consideration, then, that maximum possible accuracy is achieved if predictions for definite locations are within 2° of the actual minima.

By use of a technique more or less as outlined in the foregoing pages, minimum temperature predictions for the Lindsay district key station have been over 90 percent as an average, and occasionally 95 percent within the 2° limit. It is no doubt true that errors of more than 2° are sometimes the result of causes so confused and individually unimportant that they can be described only as meteorological accidents and as such they may occur at any time. It is probable, however, that these errors in general can be ascribed to lack of precise and timely data on air aloft over the San Joaquin Valley. The water vapor content and temperature of the air up to one or possibly two thousand feet must control to an important extent the net loss of heat at the ground: it is believed that further improvement in minimum temperature forecasting must come from quantitative investigation of these lower strata.



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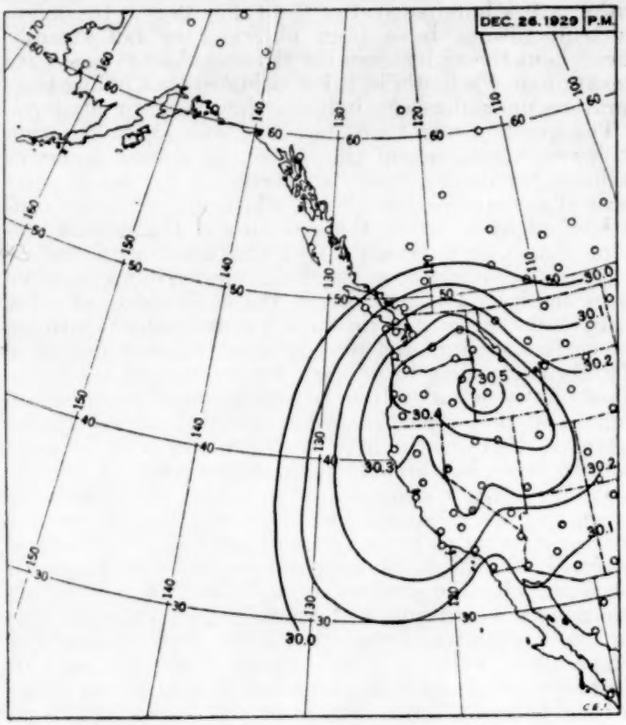

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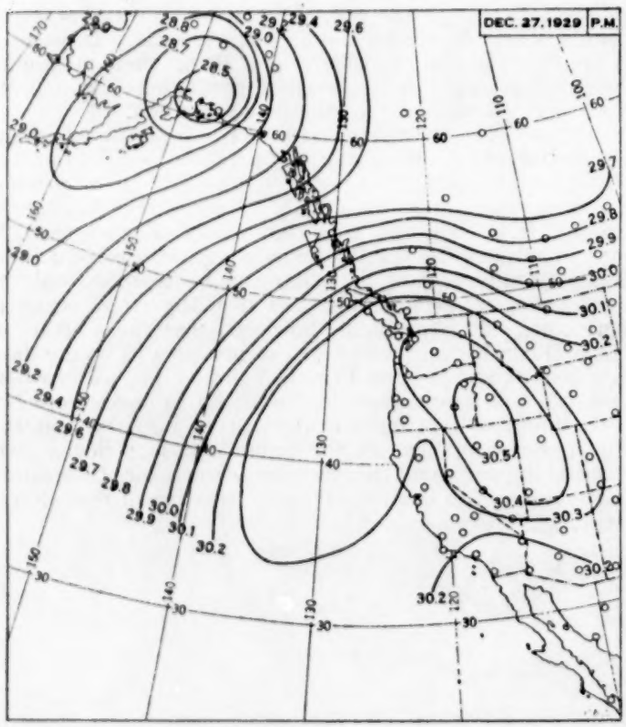

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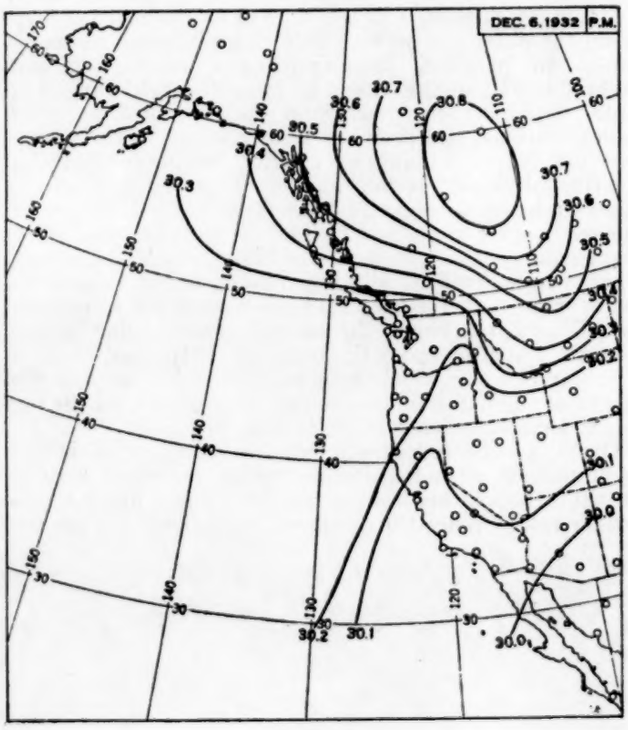

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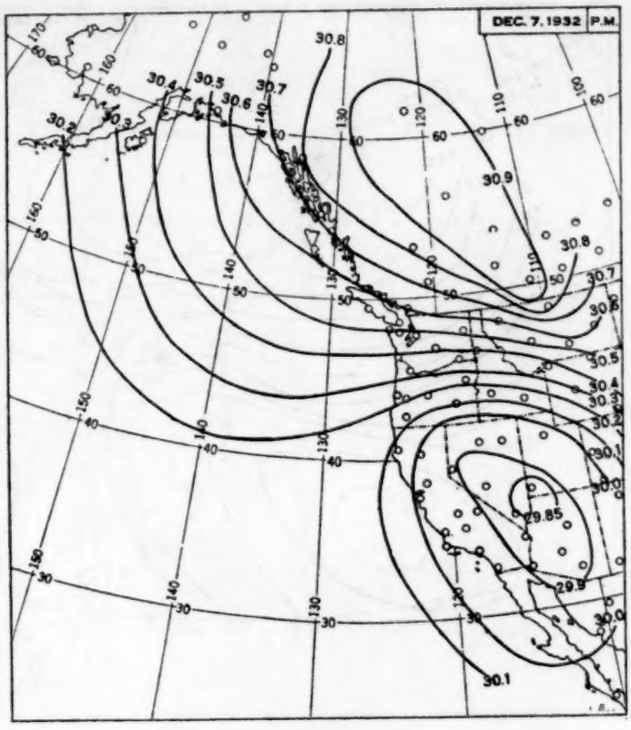

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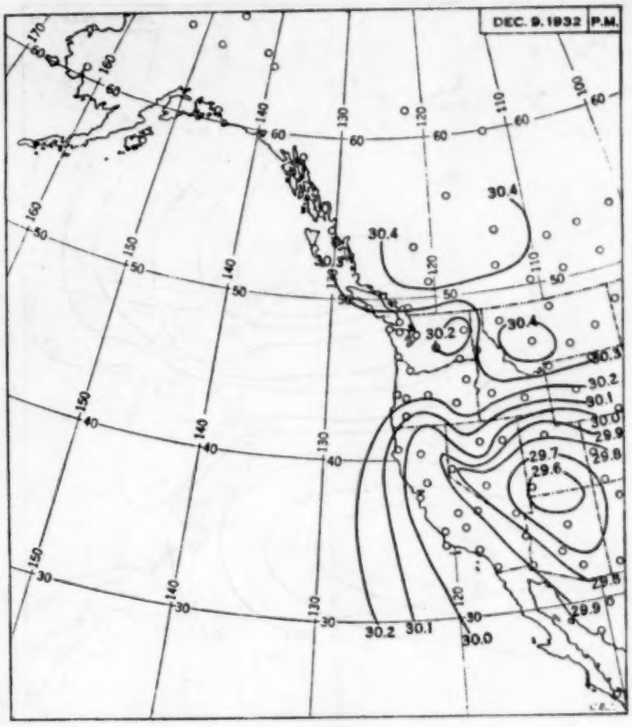

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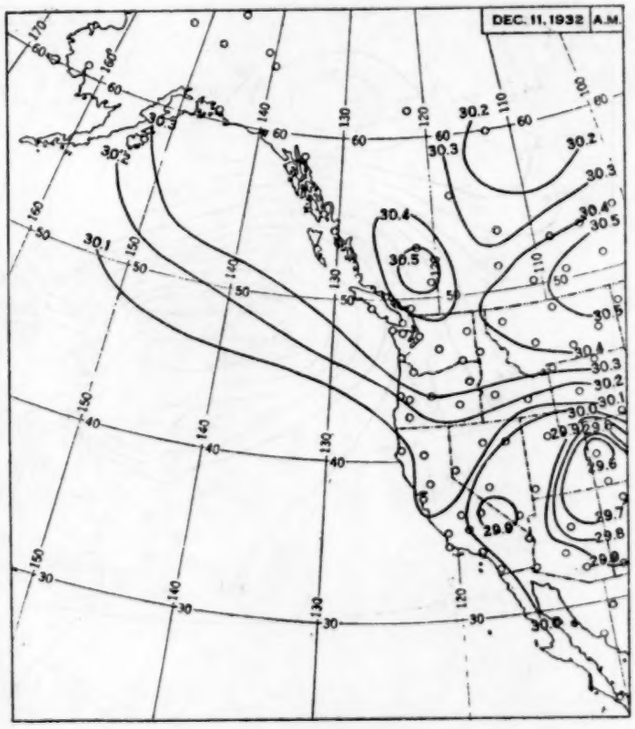

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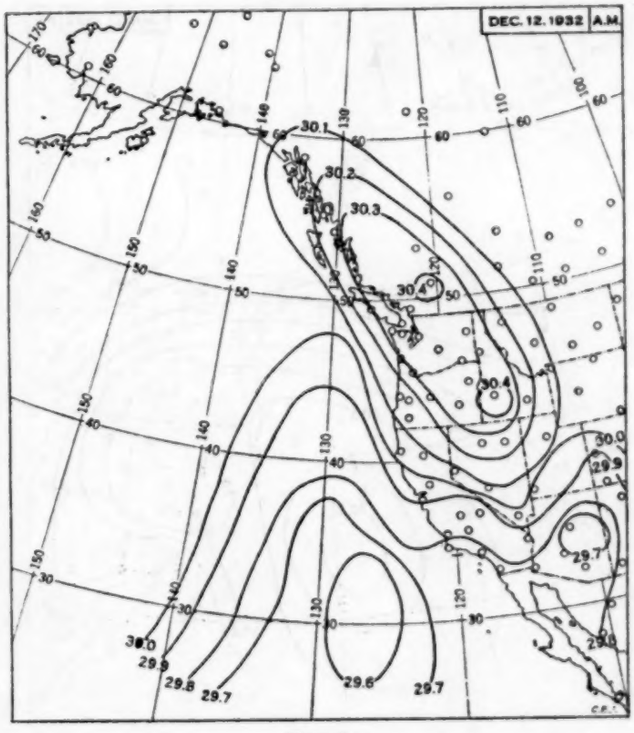

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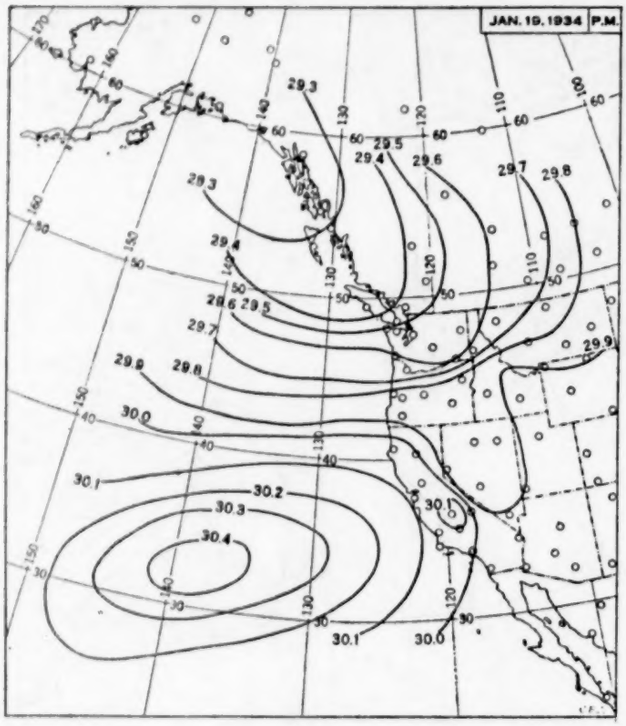

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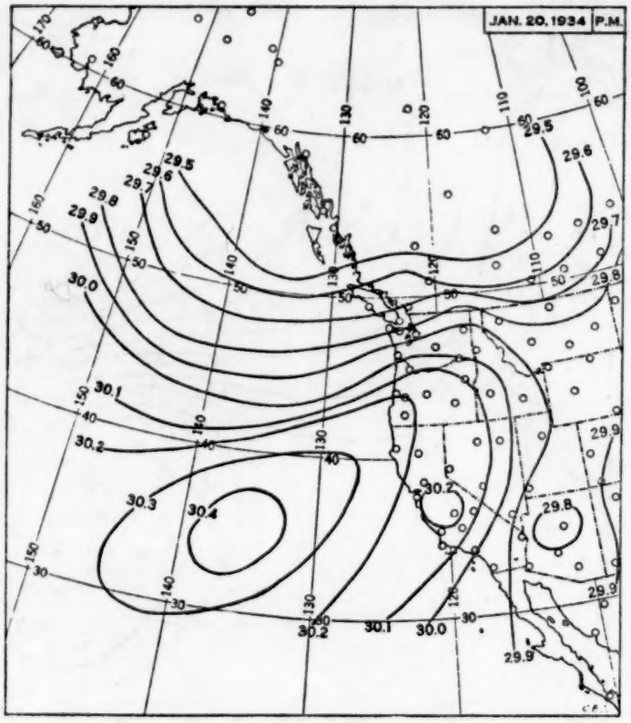

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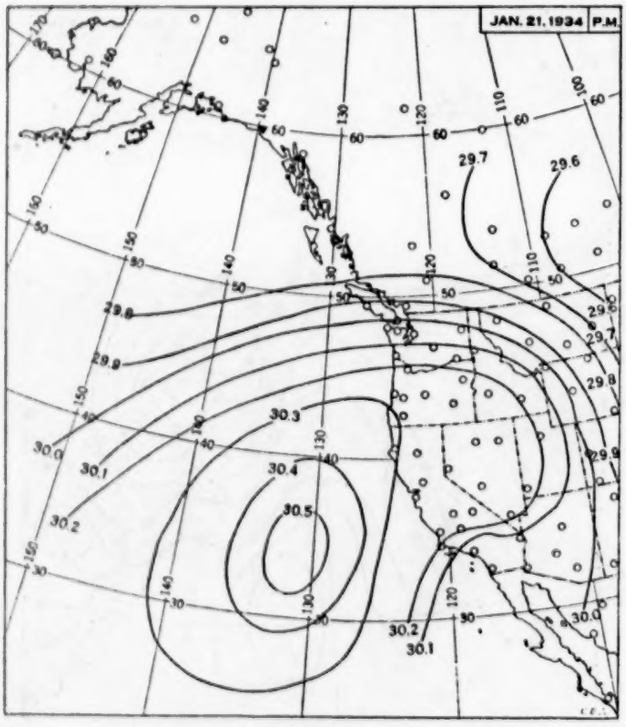

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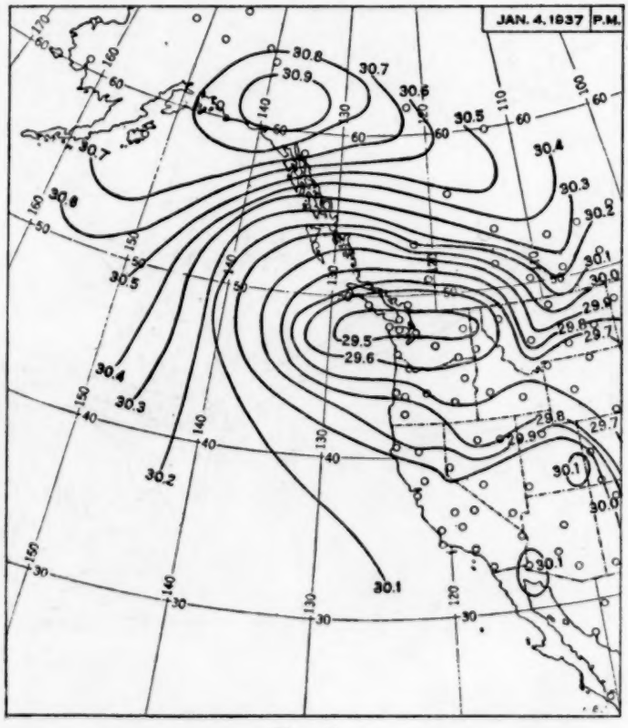

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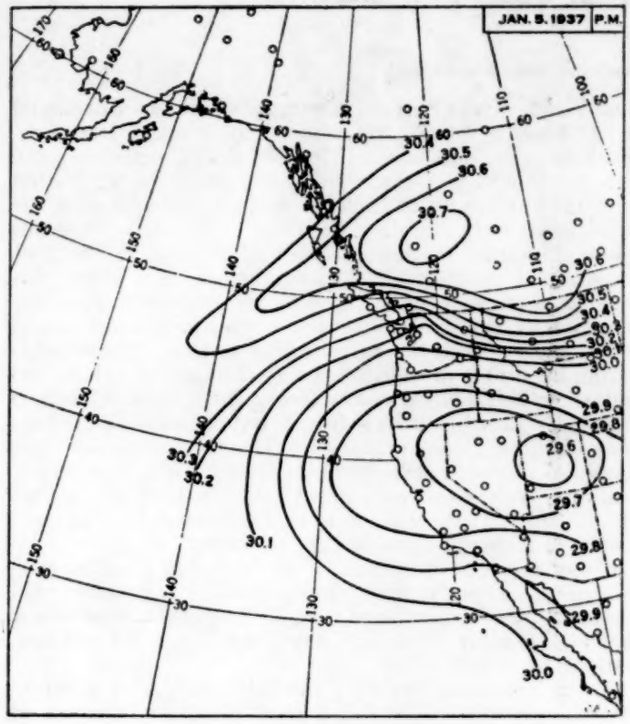

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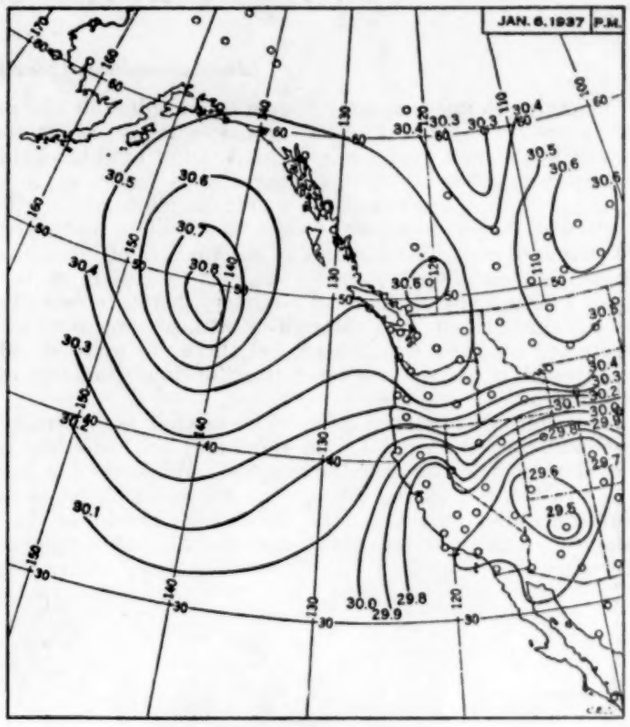

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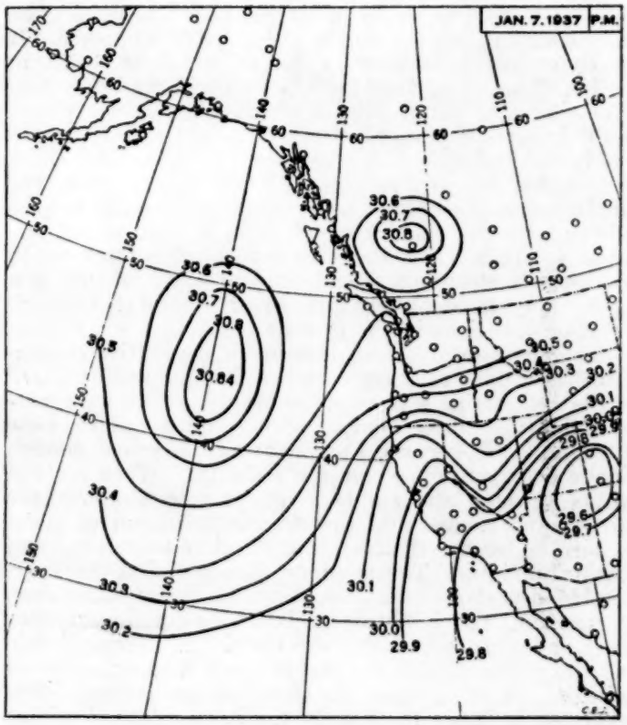

Figure 15.

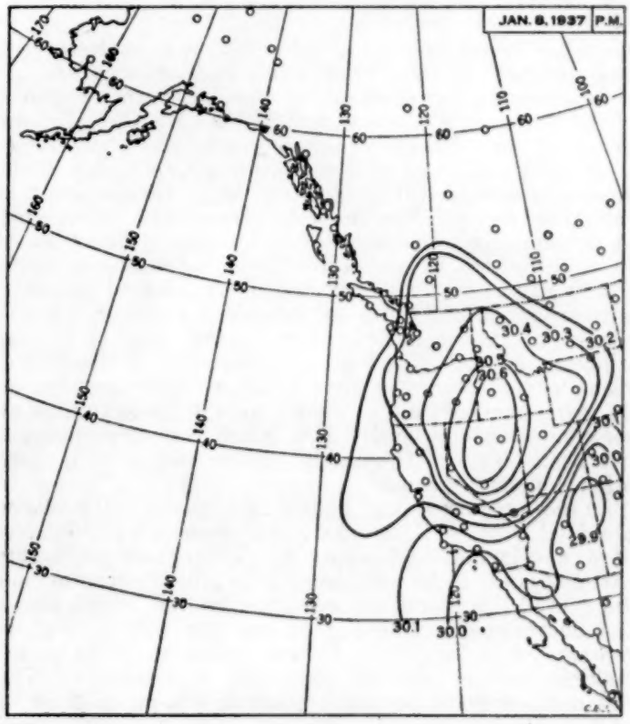

Figure 16.

ON THE DISSIPATION OF TALL CUMULUS CLOUDS

By JEROME NAMIAS

[Massachusetts Institute of Technology, Cambridge, Mass., February 1939.]

Cumulus clouds frequently tower to considerable elevations yet do not develop into cumulo-nimbus. J. Bjerknes [1] has shown that while a distribution of thin cloud columns separated by large clear spaces favors rapidly rising cumuli, there must be a certain minimum cross-section of the cloud masses or else they will be destroyed by wind shear. The manner of dissipation of cumulus-castellatus clouds is frequently difficult to explain on the basis of wind shear alone. Moreover, there are cases in which these clouds rise through an atmosphere in which there is very little wind shear, yet there are well-defined "patterns" in the sequence of forms the clouds undergo in dissipating.

A frequently-observed mode of dissipation is illustrated schematically in figure 1. In 1 (a) and (b) the cloud is developing into the castellatus type. While its top has risen in (c), a thinning process has set in which tends to cut the upper portion of the cloud from the lower. In stage (d) this process is completed and the upper portion becomes separated from the "mother" cloud. After this

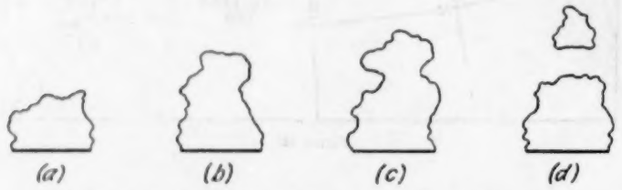

FIGURE 1.—Stages in the disintegration of a cumulus castellatus cloud.

stage has been reached the upper part is soon destroyed, and normally the lower cloud is gradually dissipated.

In a recent paper presented at the Kansas City Seminar of the American Meteorological Society, Dr. C. F. Brooks repeated the generally accepted assumption that castellatus clouds may be used as an indication that a steep lapse rate prevails in the layer where the clouds take this columnar shape. The cloud is presumably accelerated in this relatively unstable layer, tending to break away from the cloud in the stable layer below, while upon entering the more stable stratum above is forced to spread out through lateral diffusion, as against a ceiling. While this explanation may hold for vigorously growing clouds, it obviously cannot be true when the cross-section of the rising cloud column at first remains fairly constant or decreases upward, and at a later time becomes thinner at some intermediate level. This latter form of dissipation has been observed frequently by the author and many other students of clouds.

In order to throw some light on this question the author obtained from C. F. Brooks a few excellent photogaphs of a developing, and, later on, disintegrating cumulus castellatus which he took from Blue Hill Observatory on June 14, 1938. One of these photographs, which shows the characteristic thinning out in the mid-portion, is reproduced in figure 2. It was taken at 10:54 a. m. looking west-north-west from the observatory. The radiometeorograph sounding made at 6 a. m. on June 14 at East Boston, shown in figure 3, brings to light several features which may be associated with the cloud photograph. The base of these cumuli were observed by American Airlines pilots flying over the route from Boston to New York. Over Putnam, Conn., the bases were observed at 7,000 feet at 10:48 a. m., and at 6,000 feet at 1:26 p. m. and 2:36 p. m. In view of the fact that Putnam is some distance inland and that NE winds prevailed at Boston from the surface up to high levels, it is probable that the cloud bases were slightly lower nearer Boston. It seems reasonable then to place the cloud base of figure 2 at about 1,800 *m* (6,000 ft.) above sea level. Using this base as a measuring stick, and remembering that the elevation at Blue Hill is 203 *m* above sea level and is about 100 *m* higher than the surrounding terrain, it is possible to find by simple proportion the elevation of the cloud top and other well defined points (using the horizon as a fixed line). By this means, it is found that the top of the cloud is at about 5,200 *m* (535 *mb*). The thin portion of the cloud, so clearly marked in the photograph, is similarly computed to extend from about 3,400 to 3,700 *m* (670 *mb* to 650 *mb*). From these data one may sketch in figure 2 the cloud as it appeared in the picture.[2]

Under these conditions, it is evident that the thin portion of this cloud cannot be ascribed to the more rapid rise in a layer of steep lapse rate, for just in the layer where the cloud is thinnest the lapse rate is most stable—in fact, isothermal.

There are, however, two possible sources of error in this calculation. First, the cloud has been treated as though its base were directly over the horizon, while actually it is between the horizon and the observer. It may be shown, however, that this error cannot be of sufficient magnitude to vitally affect the above results. The other source of error is perhaps of more consequence. If the cloud base is in error by 200 meters or so, the thin portion of the cloud would not be found in the isothermal layer. This is admittedly a weak point in the above method, but the purpose of this illustration is to lend a clue to the problem of the dissipation of the type of cloud with which we are concerned. The author does not consider that the above observations are a proof for the following theory; they merely suggest it, and do not disprove it. It is hoped that this report will stimulate the interest of meteorologists and airplane pilots so that this theory may be definitely proven or disproven through direct observations in the free air.

The above observations indicate a dissipative mechanism based upon the suggestion, originally made by Parr,[3] that lateral mixing is most pronounced in regions of greatest stability. Some cloud columns terminate at the base of stable zones because they have not acquired enough kinetic energy to overcome the stability. When a cloud breaks through the stable layer, it towers above the surrounding clouds, and therefore is a column of moist air surrounded by air which is dry both in its relative and specific humidity. This assumes, of course, that the inversion has dry above moist air, the usual summertime case. In ascending, the cloudy air is mixed with dry air surrounding it, and this process dissipates the cloud. Mixing should be more pronounced in the stable layers than either above or below. In this manner the cloud column assumes forms suggested in figure 1. Finally the intense lateral mixing

[1] V. Bjerknes and others, Physikalische Hydrodynamik, J. Springer, Berlin.

[2] From the picture, some observers might suggest that there is a good anvil projecting toward the observer. However, this possibility is ruled out by the facts that the picture was taken looking WNW and that the upper level winds in this area (as observed by pilot balloons at Boston and Albany) show that a deep northeasterly current persisted up beyond 4,300 *m*.

[3] A. E. Parr, On the Probable Relationship between the Vertical Stability and Lateral Mixing Processes, J. du Conseil, vol. XI, No. 3, 1936.

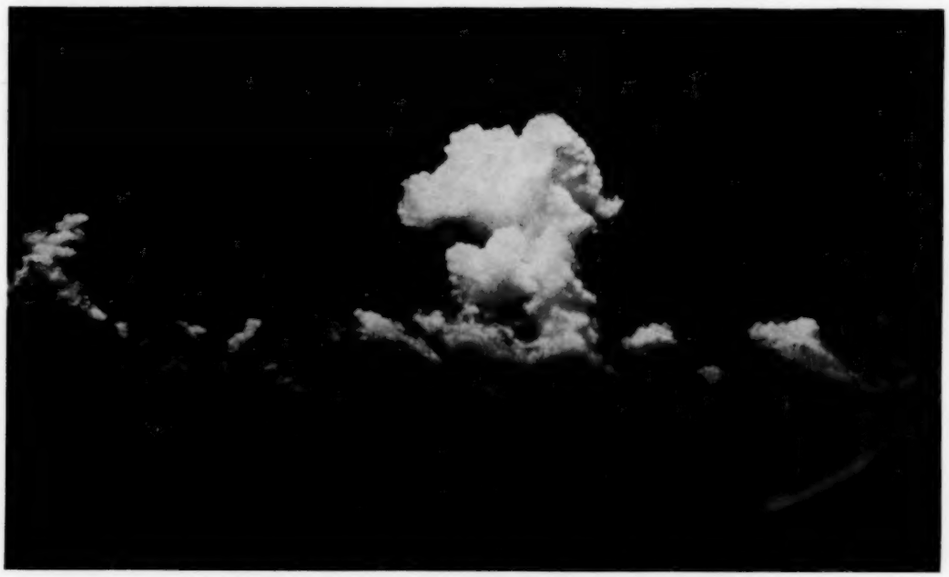

FIGURE 2.—An example of the beginning of the disintegration of a cumulus castellatus cloud.

in the middle of the cloud column severs the cloud in two, and latent heat of condensation no longer offers a supply of energy to this portion of the rising column. The upper cloudy portion is then acted upon by lateral mixing with the surrounding dry air and is soon destroyed.

A large scale picture of this cutting-off process may be observed when a moist current on the isentropic chart is being depleted of its moisture by dry air on either side, and is thus being cut off from the source of moisture. A striking case of this kind is illustrated in the vertical cross section extending from Sault Ste. Marie, Mich., to Pensacola, Fla., on June 22, 1937 (fig. 4). The pattern of moisture lines in the south is much like that suggested in figure 1c and d. The desiccating process appears to be taking place chiefly between the potential temperature isotherms 310°–315°. It is just in this layer that the vertical stability is greatest. At Pensacola, for example, from 2,430 *m* to 2,600 *m* the potential temperature increases from 310° to 314°—an inversion. Similarly, at Nashville the layer from 2,670 *m* to 3,240 *m* is isothermal (potential temperature from 310° to 315°), and at Montgomery from 1,930 *m* to 2,580 *m* the lapse rate is only 0.3°/100 *m* (potential temperature from 307° to 312°).

The fact that no large inversions of moisture appear in the Pensacola or Nashville accents, in contrast to the Montgomery ascent, shows that the upper level moist tongue is exceptionally narrow and thus presents an ideal opportunity for rapid dissipation by lateral mixing.

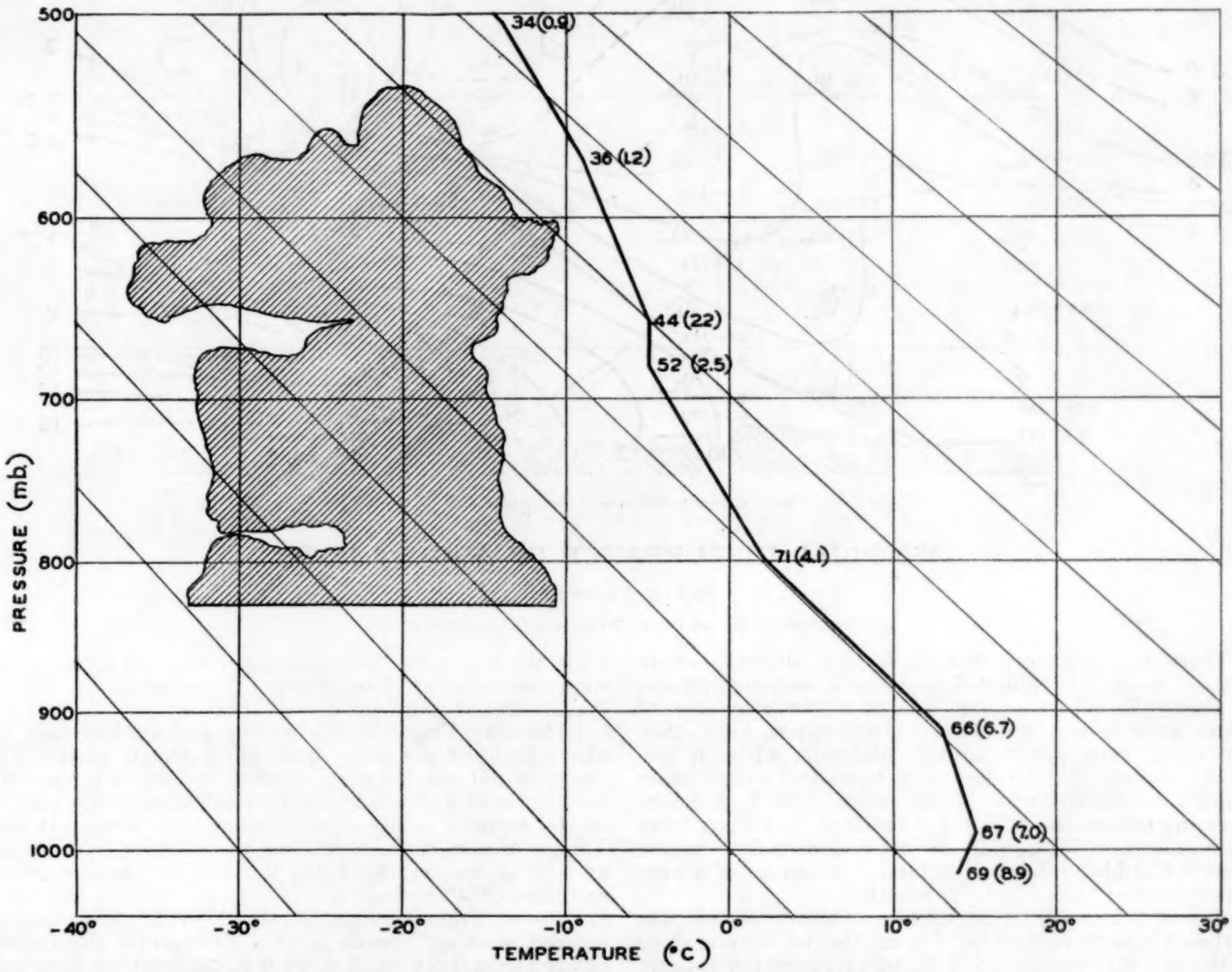

FIGURE 3.—Radiometeorograph sounding at East Boston, Mass., June 14, 1938.

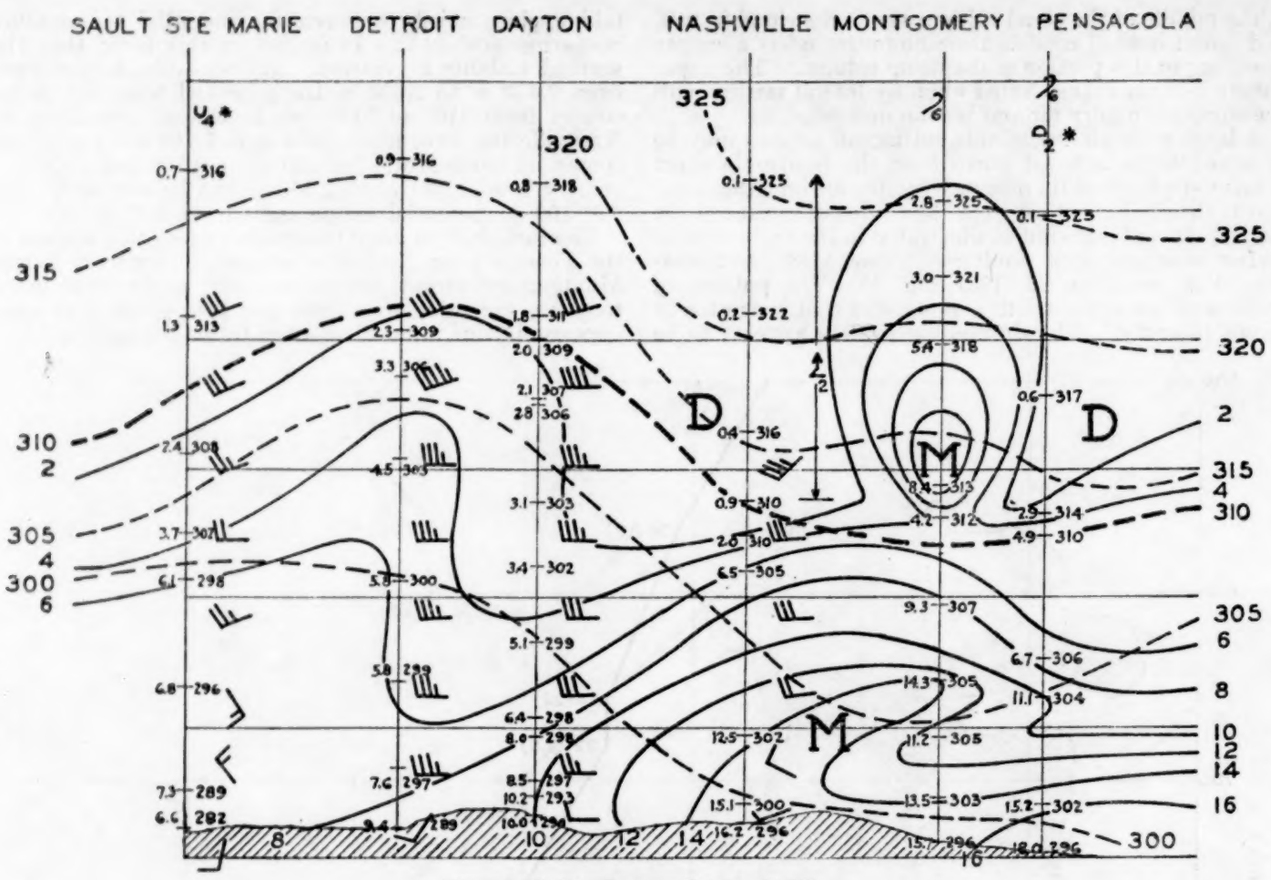

Figure 4.—North-south cross section, June 22, 1937.

TROPICAL DISTURBANCE OF AUGUST 1939

By I. R. Tannehill

[Marine Division, Weather Bureau, Washington, D. C., September 1939]

There was one well-defined tropical disturbance in August 1939. It originated in Atlantic waters northeast of Puerto Rico on the 8th, moved west-northwestward across Florida and the extreme northeastern Gulf, then progressed very slowly through Alabama, where it was nearly stationary for 3 days, and thereafter moved more rapidly northeastward to southeastern New York where it dissipated on the 20th. On the 30th and 31st, there were indications of a slight disturbance over the extreme eastern Caribbean Sea but no further evidences of it were reported after the end of the month.

August 8–20.—The first definite evidence of this disturbance was on August 8. During the day several ships in the general vicinity of 22° N., 66° W. reported easterly winds of force 6 and rough seas. The disturbance moved west-northwestward during the next 3 days, crossing the Bahamas late on the 10th and early on the 11th. The center reached the east coast of Florida in the late afternoon of the 11th. Its progressive movement had increased gradually from about 10 miles an hour on the 8th to approximately 15 miles an hour on the 10th and 11th. Ship reports do not indicate that it was of more than moderate intensity in the Atlantic. The highest wind noted on shipboard was force 10. The American steamship *Pan Amoco* reported by radio at 7 p. m., August 11, when located at 27.6° N., 79.6° W., wind E., force 10, barometer 1,005 millibars (29.68 inches).

On the east coast the lowest pressure and highest wind were recorded at Fort Pierce, 991.2 millibars (29.27 inches) and 54 miles per hour.

In crossing Florida the rate of progression increased to about 18 miles per hour, while the intensity of the disturbance did not change materially. The center passed very close to Lakeland and Tarpon Springs and moved to the extreme northeastern Gulf on the 12th. At the Tampa Airport the highest wind was 62, south-southwest at 4:30 a. m. on the 12th, the lowest pressure 998.6 millibars (29.49 inches).

Late in the afternoon of the 12th the disturbance entered western Florida near Apalachicola, the center passing over Port St. Joe, at 6 p. m., eastern standard time. At Apalachicola, lowest pressure was 990.9 millibars (29.26 inches) at 6 p. m., the highest wind 52, northeast at 4:18 p. m. A lull followed, with velocities averaging 26 miles per hour, after which the wind increased to 46 south at 6:45 p. m. The storm center also passed over Panama City and St. Andrews, the lowest reported pressure at the latter place being 988.5 millibars (29.19 inches) at 9:10 p. m.

The following comments on damage by the storm are taken from the report of Forecaster Norton at Jacksonville:

In peninsular Florida the damage by this storm was minor in character, as would be expected for a storm of only moderate

intensity. It appears that damage was confined to uprooted trees, broken power and communication lines, plate-glass windows, a few flimsy structures, roofs, signs, cornices, etc., with damage to crops negligible, although some citrus fruit was damaged and seedbeds flooded and damaged. A few small boats were beached and damaged, but small craft generally had been moved to safe anchorage well in advance of the storm. A man was drowned at Cedar Key when the rowboat in which he was attending the anchorage of fishing boats capsized in the rough sea. This was the only death attributed to the storm. In the northwestern counties from about Tallahassee to Pensacola, considerable damage to crops by flooding and wind resulted. * * *

After about 4 days in Alabama, where disastrous flooding rains fell, the remnants of the disturbance moved over the northern portion of the Jacksonville district, attended by heavy rains and some flooding along the southern and eastern slopes of the Appalachian Mountains. A tornado on the periphery of the disturbance is reported to have killed one person in North Carolina, but otherwise no very strong winds attended the disturbance in its northeastern movement in this district.

In reporting on conditions in the vicinity of Apalachicola, Forecaster Dyke at New Orleans says:

Winds of gale force occurred as far inland as De Funiak Springs, in Walton County and about 26 miles from the coast. As the stronger winds were offshore, no high tides occurred west of Apalachicola. Tides were above normal from Apalachicola northeastward to St. Marks but not high enough to cause appreciable damage.

The principal damage was to electric power, telephone, and telegraph lines. There was some damage to roofs. Most of the boats were safely placed, but a few unguarded small boats were sunk at Apalachicola. Damage of $2,000 to a dock warehouse at Port St. Joe is reported.

In Virginia, Maryland, Delaware, New Jersey, southeastern Pennsylvania, and extreme southeastern New York, heavy rains attended the remnants of the storm while it was moving northeastward during the period from the 18th to the 20th. At several places the records of rainfall in 24 hours were broken. Tuckerton, N. J., had 14.81 inches.

Timely reports, especially those received from stations in the Bahamas and from merchant ships, enabled the forecasters to chart the storm center with exceptional accuracy. Advices and warnings were issued frequently and well in advance of the storm.

Chart XIII shows the track of the disturbance and the situation on the morning of August 12 when the center was moving across the extreme northeastern Gulf of Mexico.

NOTES AND REVIEWS

DAVID BRUNT. *Physical and Dynamical Meteorology.* Second edition, 428 pp., Cambridge; at the University Press. New York; The Macmillan Co. 1939.

The first edition of this volume was published five years ago, in 1934; it remains the only general textbook and manual of mathematical meteorology in the English language. In preparing the second edition, many portions of the text have been revised, rewritten, or amplified.

The book is devoted entirely to the physical theory of the dynamic and thermodynamic phenomena in the earth's atmosphere, so far as possible in mathematical form. The comparatively small amount of descriptive material enters in only an incidental way; and there is no attempt at the discussion of weather forecasting, climatic phenomena, atmospheric optics, or other branches of the physics of the air.

The first chapter contains a brief summary of the normal distribution of temperature, pressure, and winds over the globe, the distribution of temperature in the upper air, and other basic facts of observation for which a satisfactory mathematical theory must account. The succeeding chapters discuss the fundamental static equations for the atmosphere, atmospheric stability, the thermodynamic theory of condensation, and atmospheric thermodynamics in general. Three chapters are then devoted to the role of radiation and absorption in meteorological phenomena, including the theory of the stratosphere.

The general equations of motion of the atmosphere referred to the surface of the rotating earth are then formulated, the circulation theorems developed, and the theory of the gradient wind constructed. A chapter is devoted to the dynamical theory of surfaces of discontinuity; a chapter on the general theory of turbulence is followed by a lengthy chapter on the role of atmospheric turbulence in the transfer of heat and momentum, and its effects on atmospheric stability and the variation of wind velocity with height, together with applications to the theory of evaporation into the atmosphere.

After a brief chapter in which the dynamical equations are made the basis for a classification of winds, the transformations and dissipation of energy in the atmosphere are treated, together with the theory of vortical motion in the atmosphere.

The remaining chapters of the book contrast strongly with the preceding part, in the almost complete absence of mathematical equations and in consisting predominantly of descriptive material or only generalized qualitative physical reasoning. These chapters deal with the phenomena of air masses, the frontal structure of cyclones, a review of various theoretical conceptions of cyclones and their structure in the upper air, anticyclones, and finally the general circulation of the atmosphere.—*Edgar W. Woolard.*

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By AMY P. LESHER

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SOLAR OBSERVATIONS

[Meteorological Research Division, EDGAR W. WOOLARD in charge]

SOLAR RADIATION OBSERVATIONS, AUGUST 1939

By CHARLES M. LENNAHAN

Measurements of solar radiant energy received at the surface of the earth are made at eight stations maintained by the Weather Bureau, and at nine cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at three Weather Bureau stations (Washington, D. C., Madison, Wis., Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau stations at Washington and Madison.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data, obtained up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Madison and Lincoln the observations are made with the Marvin pyrheliometer; at Washington and Blue Hill they are obtained with a recording thermopile, checked by observations with a Marvin pyrheliometer at Washington and with a Smithsonian silver disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 8 a. m. (75th meridian time) and at noon (local mean solar time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Direct radiation intensities averaged above normal for August at Madison and Lincoln, and slightly below normal at Washington.

Total solar and sky radiation was above normal at all stations except Miami and Riverside. Data for four of the regular reporting stations are not included because for various reasons the data were not available. These data will be published as soon as they are available.

TABLE 1.—*Solar radiation intensities during August 1939*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Aug. 1	15.11	.....	0.62	0.71	0.90	1.24	.....	.....	.....	.....	16.79
Aug. 2	16.20	.....	.....	.28	.54	.....	.....	.....	.....	.....	17.37
Aug. 3	17.96	.....	.....	.52	.72	.....	.....	.....	.....	.....	17.96
Aug. 5	10.59	.....	.64	.76	.....	.....	.....	.....	.....	.....	11.38
Aug. 7	15.11	.....	.61	.70	.....	.....	.....	.....	.....	.....	12.68
Aug. 10	12.68	.....	.65	.82	1.05	1.29	.....	.....	.....	.....	10.59
Aug. 11	13.13	.....	.....	.75	.88	1.14	.....	.....	.....	.....	14.10
Aug. 12	17.37	.....	.....	.....	.68	.....	.....	.....	.....	.....	15.65
Means	.....	.....	.64	.64	.78	1.22	.....	.....	.....	.....	.....
Departures	.....	.....	−.04	−.12	−.16	−.03	.....	.....	.....	.....	.....

MADISON, WIS.

Aug. 3	10.97	0.60	0.71	0.92	1.13	1.33	1.10	.....	.....	.....	9.83
Aug. 4	9.14	.77	.84	1.02	1.18	.....	.....	.....	.....	.....	8.18
Aug. 9	8.48	.84	.95	1.06	1.24	1.37	1.10	.....	.....	.....	7.57
Aug. 14	12.68	.61	.71	.84	1.03	1.30	.94	.....	.....	.....	12.24
Aug. 16	13.61	.68	.61	.80	1.02	1.22	.....	.....	.....	.....	12.68
Aug. 23	9.83	.....	.....	.96	1.15	1.35	.....	.....	.....	.....	10.21
Aug. 24	9.83	.....	.91	1.07	1.21	1.37	.....	.....	.....	.....	10.21
Aug. 25	11.38	.....	.84	1.01	1.18	1.38	.....	.....	.....	.....	12.24
Aug. 26	11.81	.....	.77	.95	1.14	1.33	.....	.....	.....	.....	11.81
Means	.....	.....	.70	.79	.96	1.14	1.33	1.05	.....	.....	.....
Departures	.....	.....	−.03	−.01	.03	.04	.04	.00	.....	.....	.....

LINCOLN, NEBR.

Aug. 2	16.20	.....	0.84	0.95	1.15	.....	1.22	1.08	0.95	.....	9.47
Aug. 3	10.59	.....	.94	1.07	1.25	.....	1.06	.96	.84	.....	7.57
Aug. 4	10.97	.....	.90	1.02	1.20	.....	1.17	.96	.....	.....	8.48
Aug. 17	13.13	0.63	.73	.87	1.08	.....	.....	.....	.....	.....	13.13
Aug. 18	12.24	.....	.73	.88	1.07	.....	1.20	1.03	.90	0.77	10.97
Aug. 21	7.29	.85	.98	1.13	1.25	.....	1.22	1.02	.90	.77	6.76
Aug. 22	8.48	.....	.....	.....	.....	.....	1.38	.....	.....	.....	8.18
Aug. 23	7.87	.79	.90	1.04	1.19	.....	1.02	.....	.....	.....	7.87
Aug. 24	9.14	.....	.....	.....	.....	.....	.92	.....	.....	.....	11.38
Aug. 26	11.38	.....	.....	.....	.70	.....	.....	.....	.....	.....	15.11
Aug. 29	12.24	.50	.63	.77	.98	.....	.....	.....	.....	.....	14.60
Aug. 30	13.13	.52	.65	.84	1.04	.....	.99	.74	.59	.45	12.68
Means	.....	.66	.81	.95	1.09	.....	1.12	.96	.84	.66	.....
Departures	.....	−.02	.03	.04	.00	.....	.05	.08	.11	.01	.....

* Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Cambridge	Fairbanks	Miami	New Orleans	Riverside	Blue Hill	San Juan	Newport
	Gram-calories per square centimeter													
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
July 30	664	614	582	599	433	666	492	400	417	412	466	492	636	608
Aug. 6	629	481	526	493	458	681	569	291	361	467	503	617	593	585
Aug. 13	478	504	476	462	361	635	440	355	476	301	488	428	610	486
Aug. 20	555	458	567	515	385	612	398	246	355	436	483	419	448	396
Aug. 27	516	473	428	470	363	618	366	275	344	476	506	390	567	345
	Departures of daily totals from normals													
July 30	+183	+138	+57	+189	+2	−1	.....	+56	−61	+18	−95	−38	+59	+80
Aug. 6	+183	+22	+23	+90	+78	+37	.....	−24	−125	+73	−29	+110	+58	+73
Aug. 13	+34	+57	−17	+54	−15	+6	.....	+60	+10	−57	−40	−82	+77	+15
Aug. 20	+136	+13	+75	+97	+49	+16	.....	−33	−112	+58	−28	−79	−85	−36
Aug. 27	+94	+62	−18	+105	+6	+37	.....	+33	−117	+77	+17	−21	+16	−87
	Accumulated departures since Jan. 1													
	+14,224	+8,736	+5,145	+14,252	+5,682	+987	.....	+595	−3,535	+4,893	−3,045	+2,156	+7,159	+2,142

POSITIONS AND AREAS OF SUN SPOTS

Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.) Superintendent, U. S. Naval Observatory. Data from measurements at the U. S. Naval Observatory from plates obtained at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's visible hemisphere. For each day, below longitude, latitude, area of spot or groups, and spot count, are given respectively the assumed longitude of the center of the disk, assumed latitude of the center of the disk, total area of spots and groups, and total spot count]

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
Aug. 1	11 23	6557	−75	314	+12	74	776	15	VG	U. S. Naval.
		6556	−52	337	−17	55	242	35		
		6553	−39	350	+5	40	12	12		
		6553	−29	0	+7	30	582	9		
		6555	+29	58	−21	39	36	8		
		6552	+34	63	−21	44	36	5		
		6550	+42	71	−23	50	121	10		
				(29)	(+6)		1,805	94		
Aug. 2	11 35	6557	−62	314	+12	61	970	25	VG	Do.
		6556	−38	338	−16	45	339	20		
		6558	−19	357	+12	20	97	10		
		6553	−16	0	+8	17	485	1		
		6553	−15	1	+5	17	97	9		
		6555	+40	56	−21	48	36	3		
		6552	+45	61	−21	50	61	6		
		6550	+55	71	−24	61	61	2		
				(16)	(+6)		2,146	76		
Aug. 3	11 30	6557	−48	315	+12	49	970	62	VG	Do.
		6556	−24	339	−16	27	242	53		
		6558	−4	359	+14	10	339	41		
		6553	−2	1	+8	3	485	9		
		6553	−1	2	+5	4	24	8		
		6553	−1	2	+10	3	24	8		
				(3)	(+6)		2,084	181		
Aug. 4	10 58	6557	−35	315	+12	35	970	30	F	Do.
		6556	−11	339	−16	24	291	21		
		6558	+10	0	+14	13	339	48		
		6553	+11	1	+8	12	485	2		
		6553	+11	1	+5	11	24	5		
				(350)	(+6)		2,109	106		
Aug. 5	11 2	6557	−22	314	+12	22	921	61	VG	Do.
		6556	+3	339	−16	23	436	34		
		6560	+15	351	−9	20	12	3		
		6560	+19	355	−4	22	6	2		
		6555	+24	0	+14	25	436	64		
		6553	+24	0	+10	25	6	1		
		6553	+25	1	+8	25	485	11		
				(336)	(+6)		2,302	176		
Aug. 6	11 55	6561	−73	250	−15	74	194	10	G	Mt. Wilson.
		6557	−13	310	+12	14	388	8		
		6557	−3	320	+12	7	485	32		
		6556	+16	339	−14	25	436	63		
		6560	+24	347	−8	29	24	4		
		6559	+28	351	−4	30	6	3		
		6558	+37	0	+15	39	388	30		
		6553	+39	2	+8	39	485	1		
				(323)	(+6)		2,406	151		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
Aug. 7	10 58	6565	−89	221	−12	89	242	1	VG	U. S. Naval.
		6566	−89	221	+17	89	242	2		
		6561	−58	252	−16	62	388	15		
		6564	−50	260	+5	50	12	2		
		6563	−33	277	−10	37	12	3		
		6557	0	310	+13	7	436	15		
		6557	+10	320	+13	12	436	27		
		6556	+30	340	−16	36	436	24		
		6560	+38	348	−9	41	6	2		
		6553	+41	351	+7	42	36	6		
		6558	+50	0	+14	50	291	2		
		6553	+51	1	+8	51	485	15		
				(310)	(+6)		3,022	114		
Aug. 8	10 49	6565	−75	222	−12	76	436	3	VG	Do.
		6566	−74	223	+17	73	242	12		
		6561	−45	252	−16	50	485	45		
		6564	−35	262	+4	35	97	22		
		6563	−17	280	−10	23	24	7		
		6562	+7	304	−8	15	97	20		
		6557	+12	309	+13	14	388	25		
		6557	+23	320	+13	25	533	50		
		6556	+43	340	−16	49	242	30		
		6553	+55	352	+7	54	6	1		
		6553	+65	2	+8	64	533	2		
		6558	+68	5	+14	68	121	6		
				(297)	(+6)		3,204	223		
Aug. 9	11 0	6567	−88	196	−19	88	242	2	VG	Do.
		6566	−61	223	+17	61	218	2		
		6565	−60	224	−13	63	582	20		
		6561	−32	252	−16	38	436	42		
		6564	−22	262	+4	22	388	16		
		6562	+21	305	−8	25	218	20		
		6557	+26	310	+13	26	339	16		
		6557	+37	321	+13	37	436	33		
		6556	+56	340	−16	59	388	25		
		6553	+78	2	+8	79	582	2		
		6558	+80	4	+14	80	121	2		
				(284)	(+6)		3,960	180		
Aug. 10	10 53	6567	−80	190	−19	80	97	6	G	Do.
		6567	−70	200	−19	73	388	4		
		6565	−48	222	−13	51	242	15		
		6566	−47	223	+17	46	291	10		
		6565	−43	227	−12	45	291	4		
		6569	−40	230	+17	42	6	3		
		6561	−19	251	−17	29	485	41		
		6564	−7	263	+4	7	485	20		
		6563	+9	279	−11	19	12	5		
		6562	+35	305	−8	38	194	14		
		6557	+38	308	+13	37	291	15		
		6568	+46	316	−24	55	121	18		
		6557	+49	319	+13	48	436	18		
		6556	+68	338	−16	70	339	21		
				(270)	(+6)		3,678	194		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
Aug. 11..	11 3	6570	−88	169	+12	82	291	2	G	U. S. Naval.
		6567	−66	191	−19	71	194	10		
		6567	−56	201	−19	61	339	9		
		6566	−34	223	+17	35	218	3		
		6565	−30	227	−12	36	388	18		
		6569	−26	231	+16	27	36	9		
		6561	−5	252	−17	24	485	58		
		6564	+7	264	+4	7	630	23		
		6562	+49	306	−8	51	291	8		
		6557	+51	308	+13	52	242	8		
		6568	+60	317	−23	66	48	3		
		6557	+61	318	+12	62	388	11		
		6556	+83	340	−14	86	24	1		
				(257)	(+6)		3,574	163		
Aug. 12..	11 2	6572	−88	156	−7	88	145	2	G	Do.
		6570	−71	173	+12	71	194	2		
		6567	−52	192	−19	58	194	24		
		6567	−44	200	−19	50	388	9		
		*	−31	213	−15	37	6	2		
		6566	−21	223	+17	24	206	48		
		6565	−17	227	−13	26	679	50		
		6561	+9	253	−17	14	436	69		
		6571	+11	255	+17	16	194	27		
		6564	+16	260	+4	16	291	16		
		6564	+23	267	+4	24	242	12		
		6562	+63	307	−8	65	267	15		
		6557	+65	309	+13	66	242	7		
		6568	+74	318	−23	79	24	9		
		6557	+76	320	+12	74	388	4		
				(244)	(+6)		3,896	296		
Aug. 13..	11 27	6572	−73	157	−8	74	242	3	F	Mt. Wilson.
		6570	−59	171	+12	58	133	2		
		6567	−39	191	−19	42	194	3		
		6567	−31	199	−19	34	388	13		
		6566	−8	222	+17	12	194	1		
		6565	−4	226	−13	20	582	75		
		6561	+21	251	−17	30	388	56		
		6571	+23	253	+17	25	242	40		
		6564	+30	260	+4	30	242	16		
		6573	+34	264	+22	36	48	4		
		6564	+38	268	+4	38	194	8		
		6563	+50	280	−9	50	6	3		
		6562	+78	308	−7	78	97	4		
		6557	+80	310	+13	79	145	5		
				(230)	(+7)		3,095	233		
Aug. 14..	10 53	6572	−60	157	−8	62	291	9	G	Do.
		6570	−45	172	+12	44	97	13		
		6567	−18	199	−19	31	533	27		
		6566	+7	224	+16	13	194	1		
		6565	+10	227	−13	15	388	95		
		6561	+36	253	−17	43	48	30		
		6571	+37	254	+17	38	267	28		
		6561	+41	258	−17	48	242	1		
		6564	+44	261	+4	44	242	30		
		6573	+48	265	+23	50	24	2		
		6564	+51	268	+5	32	194	15		
				(217)	(+7)		2,520	261		
Aug. 15..	10 59	6577	−85	119	−31	88	48	1	G	U. S. Naval
		6576	−81	123	+12	80	339	3		
		6572	−47	157	−8	49	291	5		
		6570	−32	172	+12	33	61	15		
		6567	−4	200	−19	25	485	12		
		6574	−2	202	+16	10	48	13		
		6575	+11	215	+14	13	24	2		
		6566	+20	224	+17	23	194	3		
		6565	+23	227	−13	25	388	45		
		6561	+46	250	−17	50	48	12		
		6571	+50	254	+17	50	267	23		
		6561	+52	256	−17	56	242	13		
		6564	+60	264	+4	60	533	40		
		6573	+60	264	+23	61	6	1		
				(204)	(+7)		2,974	188		
Aug. 16..	11 9	6576	−79	112	+13	76	388	19	G	Do.
		6577	−70	121	−31	78	194	1		
		6576	−68	123	+12	68	582	4		
		6572	−33	158	−8	36	291	5		
		6570	−19	172	+12	20	24	7		
		6567	+9	200	−19	18	485	13		
		6574	+11	202	+17	16	121	30		
		6566	+32	223	+16	33	194	5		
		6565	+37	228	−13	39	242	25		
		6561	+59	250	−19	62	12	1		
		6571	+64	255	+16	63	170	8		
		6561	+67	258	−17	70	291	7		
		6564	+73	264	+3	72	630	20		
				(191)	(+7)		3,624	145		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
Aug. 17	10 50	6576	−66	112	+13	53	533	30	VG	U. S. Naval.
		6577	−57	121	−32	67	145	1		
		6576	−54	124	+12	53	582	6		
		6572	−20	158	−8	25	291	3		
		6570	−4	174	+12	6	24	6		
		6567	+22	200	−19	33	436	10		
		6574	+24	202	+17	26	388	42		
		6566	+45	223	+16	45	194	2		
		6565	+45	223	−14	50	24	4		
		6565	+50	228	−13	55	170	16		
		6561	+82	260	−17	86	291	6		
		6571	+83	261	+17	80	145	2		
		6564	+84	262	+3	81	436	4		
				(178)	(+7)		3,659	132		
Aug. 18..	14 14	6578	−71	92	−17	75	97	3	F	Mt. Wilson.
		6576	−49	114	+13	49	485	30		
		6577	−43	120	−31	55	73	1		
		6576	−39	124	+13	39	533	25		
		6572	+5	156	−7	15	145	2		
		(*)	+7	170	−26	35	12	4		
		6570	+11	174	+13	13	12	3		
		6567	+35	198	−19	43	436	20		
		6574	+39	202	+17	40	339	25		
		6566	+60	223	+16	60	73	2		
		6565	+63	226	−13	66	97	9		
				(163)	(+7)		2,302	124		
Aug. 19..	13 25	6579	−84	66	+13	82	24	1	P	Do.
		6578	−61	89	−19	65	48	2		
		6576	−37	113	+13	36	485	20		
		6577	−31	119	−31	48	121	1		
		6576	−28	122	+12	27	582	12		
		6572	+8	158	−7	16	145	4		
		6570	+22	172	+15	23	12	2		
		6567	+48	198	−19	53	436	14		
		6574	+53	203	+17	54	291	15		
		6566	+71	221	+17	70	73	1		
				(150)	(+7)		2,217	72		
Aug. 20..	11 43	6579	−70	68	+13	69	291	14	F	U. S. Naval.
		6578	−48	90	−19	53	24	4		
		6576	−24	114	+13	25	679	25		
		6577	−19	119	−32	43	48	2		
		6576	−14	124	+12	15	679	13		
		6572	+22	166	−8	26	339	13		
		6567	+62	200	−19	66	582	17		
		6574	+62	200	+16	63	97	5		
		6574	+70	208	+16	70	194	2		
		6566	+88	226	+16	82	97	1		
				(138)	(+7)		3,030	96		
Aug. 21..	11 56	6579	−57	67	+13	56	485	19	G	Do.
		6576	−11	113	+13	13	679	56		
		6577	−7	117	−32	39	97	1		
		6576	−2	122	+12	5	679	28		
		6572	+35	159	−8	37	291	6		
		6567	+76	200	−20	75	582	2		
		6574	+77	201	+16	76	97	3		
		6574	+86	210	+16	86	194	1		
				(124)	(+7)		3,104	116		
Aug. 22..	11 0	6581	−88	24	−11	86	48	1	G	Do.
		6579	−43	69	+13	43	436	15		
		6580	−41	71	−20	48	24	8		
		6578	−2	110	+15	10	145	15		
		6576	+2	114	+13	8	436	35		
		6577	+6	118	−32	39	97	1		
		6576	+12	124	+11	13	630	5		
		6572	+49	161	−8	50	242	1		
				(112)	(+7)		2,058	81		
Aug. 23..	11 34	6581	−75	23	−12	76	267	1	G	Do.
		6582	−71	27	−12	73	24	8		
		6579	−30	68	+13	31	315	5		
		6580	−28	70	−21	34	24	3		
		6576	+12	110	+15	15	73	8		
		6576	+17	115	+13	18	339	21		
		6577	+20	118	−32	41	97	2		
		6576	+26	124	+12	27	582	9		
		6572	+62	160	−8	64	291	1		
				(98)	(+7)		2,012	58		
Aug. 24..	11 13	6581	−61	24	−12	63	145	4	VG	Do.
		6582	−58	27	−12	61	48	5		
		6579	−17	68	+13	17	291	7		
		6580	−15	70	−21	31	12	3		
		6583	+16	101	−14	26	12	6		
		6576	+26	111	+15	29	73	16		
		6576	+28	113	+13	28	242	14		
		6577	+32	117	−32	48	97	1		
		6576	+39	124	+12	39	582	6		
		6572	+74	159	−9	76	291	1		
				(85)	(+7)		1,793	63		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
Aug. 25	11 51	6581	−49	23	−12	51	194	11	VG	Mt. Wilson.
		6582	−42	30	−13	56	73	15		
		6579	−3	69	+13	7	242	13		
		6580	−2	70	−21	27	6	4		
		6583	+30	102	−13	36	48	6		
		6576	+42	114	+13	41	145	8		
		6577	+46	118	−32	56	97	1		
		6576	+52	124	+13	61	533	8		
				(72)	(+7)		1,338	66		
Aug. 26	11 40	6585	−73	345	−17	70	436	17	VG	U. S. Naval.
		6584	−60	358	+7	60	24	5		
		(*)	−55	3	−5	54	24	5		
		6581	−34	24	−12	37	218	16		
		6582	−28	30	−13	33	97	10		
		6579	+10	68	+13	12	242	12		
		6580	+13	71	−21	29	12	7		
		6576	+53	111	+16	53	48	12		
		6576	+55	113	+12	55	133	3		
		6577	+59	117	−32	65	97	1		
		6576	+66	124	+12	64	582	10		
				(58)	(+7)		1,913	98		
Aug. 27	9 14	6586	−67	340	−9	68	242	19	VG	Mt. Wilson.
		6585	−60	347	−17	62	679	46		
		6584	−47	0	+7	47	36	8		
		6581	−22	25	−12	27	145	25		
		6582	−16	31	−12	25	97	21		
		6579	+23	70	+13	22	145	9		
		6576	+66	113	+12	65	97	4		
		6577	+69	116	−32	73	97	5		
		6576	+79	126	+12	77	388	6		
				(47)	(+7)		1,926	143		
Aug. 28	11 4	6587	−80	312	−8	79	97	2	F	Do.
		6586	−52	340	−9	53	242	16		
		6585	−47	345	−16	50	582	48		
		6581	−9	23	−12	19	48	18		
		6582	−2	30	−11	17	12	8		
		6579	+37	69	+13	37	121	6		
		6576	+80	112	+12	78	73	3		
				(32)	(+7)		1,175	101		
Aug. 29	11 0	6587	−67	312	−8	65	109	2	VG	U. S. Naval.
		(*)	−61	318	+14	72	24	4		
		6585	−43	336	−16	47	12	1		
		6586	−42	337	−9	43	242	2		
		6586	−35	344	−8	36	145	13		
		6585	−33	346	−16	39	1,212	55		
		6581	+7	26	−12	19	48	8		
		6581	+11	30	−9	18	12	2		
		6579	+52	71	+13	52	194	3		
				(19)	(+7)		1,998	90		
Aug. 30	11 0	6587	−53	313	−8	52	97	5	G	Do.
		6586	−28	338	−9	32	242	3		
		6586	−23	343	−8	26	242	22		
		6585	−18	348	−16	27	1,454	70		
		6589	−13	353	+7	12	36	7		
		6589	−8	358	+7	8	24	5		

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1939	h m		°	°	°	°				
Aug. 30	11 0	6588	−8	358	+27	23	97	14	G	U. S. Naval.
		(*)	+26	32	−8	27	12	4		
		6579	+66	72	+13	64	194	3		
				(6)	(+7)		2,398	133		
Aug. 31	11 3	6591	−81	272	+5	81	145	1	VG	Do.
		6587	−41	312	−8	43	145	13		
		6586	−15	338	−8	20	194	14		
		6586	−9	344	−8	16	194	45		
		6585	−6	347	−15	22	2,036	74		
		6589	0	353	+7	0	12	3		
		6588	+3	356	+29	23	12	4		
		6588	+7	0	+27	24	48	5		
		6590	+44	37	−5	45	6	1		
		6579	+79	72	+13	78	145	4		
				(353)	(+7)		2,937	164		

Mean daily area for 31 days=2,589.
* Not numbered.
Plate quality: P, poor; F, fair; G, good; VG, very good.

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR AUGUST 1939

[Dependent alone on observations at Zurich]

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich Switzerland]

August 1939	Relative numbers	August 1939	Relative numbers	August 1939	Relative numbers
1	*Ecd* 67	11	*aa* 157	21	*b* 94
2	78	12	*Mac* 170	22	86
3	Maac 73	13	*ad* 159	23	*d* 72
4	94	14	*a* 138	24	75
5	*a* 90	15	*Macd* 146	25	*a* 58
6	*d* 112	16	122	26	*d* 69
7	*Mbc* 106	17	128	27	*Ec* 86
8	*Edd* 141	18	111	28	85
9	157	19	*a* 110	29	69
10	*d* 157	20	*d* 104	30	*Mc* 76
				31	*b* 95

Mean, 31 days=105.8

a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central-circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By B. FRANCIS DASHIELL

Upper-air observations made during August by airplanes and radiosonde are given in tables 1 and 1a, respectively, while those made by pilot balloons are shown in tables 2 and 3. The resultant winds, as well as the mean free-air pressures and temperatures, are shown on charts VIII, IX, X and XI. Isentropic data are given on chart XII and the mean altitudes of the identified tropopauses are shown in table 4. Detailed explanations of these charts and tables will be found in the January 1939 issue of the MONTHLY WEATHER REVIEW.

Table 1 shows that airplane observations are made at 7 stations in the United States. These observations failed to indicate any unusual pressure, temperature or humidity means for August. The highest temperatures prevailed at 1.5, 3, 4 and 5 kilometers on the Pacific coast (Seattle, Wash., and San Diego, Calif.). Mean pressure was highest over Pensacola, Fla., at 1.5 and 3 kilometers, and over San Diego, Calif., at 4 and 5 kilometers. Humidities were highest over Lakehurst, N. J., and Washington, D. C., and lowest over Seattle, Wash.

The radiosonde observations given in table 1a, as well as the airplane flights in table 1, show that below-zero mean temperatures were not encountered until nearly 5 kilometers was reached over all stations, except Miami, Fla. At 5 kilometers lowest mean temperatures occurred over Billings, Mont. (−5.3° C.), while the highest was over Miami, Fla. (+0.8° C.). But above 5 kilometers, where all observations are made by radiosonde (table 1a), the lowest mean temperatures were found at the 16-kilometer level, except at 15 kilometers over Omaha, Nebr.,

and 17 kilometers at San Juan, P. R. Mean minimum temperatures for August were found over El Paso, Tex. (−72.1° C.), San Juan, P. R. (−70.2° C.), Albuquerque, N. Mex. (−70.1° C.), and Phoenix, Ariz. (−70.0° C.). These were slightly lower than the minima recorded at more northern stations during the current month as well as in August 1938. Individual radiosonde observations showed that temperatures colder than −75.0° C. were recorded over San Juan, P. R., Washington, D. C., El Paso, Tex., and Albuquerque, N. Mex.

August resultant-wind directions and forces, based on 5 a. m. (Eastern standard time) observations made at 1.5 and 3 kilometers, and 5 p. m. observations at 4 and 5 kilometers, are shown on charts VIII, IX, X and XI, respectively. West of the Mississippi practically all pilot-balloon stations reached maximum altitudes of 10 kilometers or more, while 20 percent of all stations in the United States reported individual ascents that exceeded 15 kilometers. In the latter group many of these stations were located along a belt reaching from Texas to North Dakota. At Abilene, Tex., and Omaha, Nebr., individual flights exceeded 20 kilometers, and over Florida, eastern Colorado, Wyoming and Montana, all stations reached 15 kilometers or more. East of the Mississippi, except in Florida and a portion of the Ohio Valley, New England and the middle Atlantic States area, maximum altitudes for August failed to exceed 10 kilometers. The 13th and 14th of the month appeared favorable for high observations in the West, and the 15th and 17th in the East.

Individual wind speeds encountered during August above 15 kilometers were not unusual. The greater wind velocities were confined to the lower levels, as shown in table 3. Highest velocities reported between 15 and 26 kilometers were: 27, 18, 10, 15, 21, 17, 11, 14, 12, 13, 14 and 20 meters per second, respectively. A number of these observations indicated that winds having easterly components existed above 15 kilometers. This was particularly true above Abilene, Tex., between 16 and 26 kilometers. Upper-air wind observations covering the Southeast and Gulf States, as well as New Mexico, Arizona and southern California, showed that easterly winds persisted at the maximum altitudes reached. Similar conditions also were observed farther north, over Omaha, Nebr., and Huron, S. Dak.

The 5 a. m. (Eastern standard time) resultant-wind directions at 1.5 kilometers, as shown on chart VIII, were southwesterly over the greater portion of the United States. However, northwesterly winds were recorded over Atlanta, Ga., Birmingham, Ala., and Jackson, Miss., which appeared to be indications of the belt of northwesterly winds existing above at 3, 4, and 5 kilometers. Southeasterly winds prevailed over southern Texas, but directions were somewhat confused over the Pacific States, where velocities were light. Rather high resultant velocities were noted at 1.5 kilometers over the East, except for an area embracing Atlanta, Ga., Birmingham, Ala., Mobile, Ala., and New Orleans, La. High resultant velocities were recorded over Texas and Oklahoma; the extreme for the United States being 9.3 meters per second at Amarillo, Tex. Very low velocities of 1 meter per second or less were reported from the Pacific Northwest and southern California.

At 3 kilometers the resultant winds, based on 5 a. m. observations and shown on chart IX, indicated considerable change from those at 1.5 kilometers (chart VIII). A wide belt of northwesterly winds stretched across the country diagonally from Montana to Georgia, while westerly winds prevailed generally over the Northeast and the central Rocky Mountain region. Elsewhere southerly and southwesterly winds occurred, except southeasterly over Texas and Key West, Fla. A sharp line of demarcation between these southeasterly and northwesterly winds was located over northern and eastern Texas and western Louisiana. The resultant velocities over the south-central States, which were greatest at 1.5 kilometers, became the lowest for the country at 3 kilometers. High wind velocities occurred along the northern border, reaching maximum speeds of 7.5 and 8.2 meters per second at Havre, Mont., and Sault Ste. Marie, Mich., respectively. Relatively high velocities were noted over the Pacific and Atlantic coasts, the far Northwest, the Dakotas and the northeastern States.

Chart X shows the resultant winds at 4 kilometers, but based on 5 p. m. (Eastern standard time) observations. As also shown on chart IX for 3 kilometers, the belt of northwesterly winds stretching across the country to the Gulf coast and Georgia was flanked by a smaller area of southeasterly winds over Texas. Southwesterly winds occurred over the far West, the Southeast, and New England. Resultant velocities were highest over the north-central States from Montana to Michigan, and for the entire country over Des Moines, Iowa, and Omaha, Nebr. (9.8 and 10.0 meters per second, respectively).

At 5 kilometers, as shown on chart XI, the predominating winds over most of the United States came from the northwest quadrant, except along the Atlantic and Pacific coasts, Florida, southern Texas, and Arizona. Winds from the northeast quadrant occurred over a narrow belt from Abilene, Tex., to Birmingham, Ala. Easterly resultant winds persisted over southern Texas at 5 kilometers and continued in individual cases to 26 kilometers. Resultant velocities at 5 kilometers were high over the northern and eastern sections of the United States except in the far Northwest and lower Great Lakes region. The extreme Southwest reported low resultant velocities, being less than 1 meter per second at Winslow, Ariz. The highest velocities occurred over Havre, Mont. (11.0 meters per second), Bismarck, N. Dak. (11.0 meters per second), Fargo, N. Dak. (11.3 meters per second), and Des Moines, Iowa (10.7 meters per second). Velocities were somewhat lower over the East, ranging from 10.5 meters per second at Sault Ste. Marie, Mich., and 8.8 meters per second at Detroit, Mich., to 7.9 meters per second at Albany, N. Y.

Comparing the 5 a. m. August resultant-wind directions and velocities at 1.5 and 3 kilometers with 5 a. m. normals for 24 stations in the United States, it was found that large variations occurred over Medford, Oreg. (departure of 147° by a clockwise rotation from normal), Atlanta, Ga. (37° clockwise), and Nashville, Tenn. (25° counterclockwise), at 1.5 kilometers; and over Oklahoma City, Okla. (68° clockwise), Houston, Tex. (41° clockwise), and Billings, Mont. (40° clockwise), at 3 kilometers. Normal current directions were noted over Oklahoma City, Okla., at 1.5 kilometers, and Atlanta, Ga., St. Louis, Mo., and Fargo, N. Dak., at 3 kilometers. Departures from normal at 1.5 kilometers were by counterclockwise rotations, except over the Gulf and southeastern States and the far Northwest and Pacific coast where the departures were clockwise. At 3 kilometers all current departures of direction from normal by counterclockwise rotations were confined to the north-central and northeastern States.

Resultant velocities for August were less than normal at 1.5 kilometers over the entire country, except Billings, Mont., Sault Ste. Marie, Mich., and Oklahoma City, Okla. Outstanding negative departures occurred along the north Atlantic coast (Washington, D. C., −2.3 meters per second, and Boston, Mass., −2.2 meters per second), while Chicago, Ill., and Houston, Tex., showed normal

resultant velocities during August. At 3 kilometers velocities were less than normal except on the Pacific coast (Seattle, Wash., +1.3 meters per second) and along a belt extending from the Southwest to St. Louis, Mo. (+1.2 meters per second). The greatest negative velocity departure occurred at Boston, Mass. (−5.0 meters per second), while the largest positive departure was noted at Oklahoma City, Okla. (+1.5 meters per second). August resultant velocities at 3 kilometers over Atlanta, Ga., and Billings, Mont., were normal.

Although normal winds have been computed from morning observations only, a comparison of the 5 p. m. winds for August with corresponding 5 a. m. normals indicated that the departures in direction at 4 kilometers were by clockwise rotations over the Southwest and Southeast at 5 kilometers. Large departures of current direction from normal were noted at Oklahoma City, Okla. (139° counterclockwise), Houston, Tex. (124° counterclockwise), and Atlanta, Ga. (40° clockwise), at 4 kilometers; and over Albuquerque, N. Mex. (163° clockwise), Oklahoma City, Okla. (82° counterclockwise), and Houston, Tex. (153° counterclockwise), at 5 kilometers. The 5 p. m. resultant wind velocities for August were less than normal at 4 kilometers, except over the Central States at 4 kilometers; and greater than normal everywhere except over Seattle, Wash., Houston, Tex., and Cincinnati, Ohio, at 5 kilometers.

When the 5 p. m. winds for August were compared with the 5 a. m. normals for *all* levels above the surface up to 5 kilometers at 19 selected stations, it was found that Cincinnati, Ohio, Omaha, Nebr., Chicago, Ill., Fargo, N. Dak., and Nashville, Tenn. (in the same general area), had wind directions that were nearly normal. The greatest departures were noted over the West, being centered at Albuquerque, N. Mex., Salt Lake City, Utah., Seattle, Wash., Billings, Mont., Oakland, Calif., and Cheyenne, Wyo. At Albuquerque, N. Mex., the current winds departed by 71°, 22°, 126°, 116°, and 163° with clockwise rotations from normal at 2, 2.5, 3, 4, and 5 kilometers, respectively, and at Salt Lake City, Utah, by 150°, 130°, 154°, 42°, 26°, and 22°, by clockwise rotations, at 1.5, 2, 2.5, 3, 4, and 5 kilometers, respectively. Resultant velocities that were less than normal were outstanding at Fargo, N. Dak., Cincinnati, Ohio, Houston, Tex., Salt Lake City, Utah, St. Louis, Mo., and Washington, D. C., at all levels, but at Medford, Oreg., and Oakland, Calif., departures were greater than normal.

Table 2 shows the 5 p. m. (Eastern standard time) resultant winds for all levels where computed. Comparing these for 1.5 kilometers with the winds at 5 a. m. (Eastern standard time) for August it was noted that the 5 p. m. wind directions turned away from the morning winds by clockwise rotations over the East, Southeast, and central Rocky Mountains. Elsewhere the afternoon directions showed diurnal changes by assuming counterclockwise rotations from the morning directions. However, at 3 kilometers, the 5 p. m. winds having counterclockwise departures from the 5 a. m. directions were located over the lower Mississippi valley, the Northeast and the far Northwest. At 1.5 kilometers the 5 p. m. resultant-wind velocities over the country were lighter than those occurring in the morning except in the Northwest, but at 3 kilometers the afternoon velocities were higher at all places except over the Great Lakes region, the south Atlantic coast, and Texas.

Table 3 shows the maximum individual wind velocities during August. The wind speed of 40.4 meters per second over Wichita, Kans., was the highest to be reported from below 2.5 kilometers during recent years. The maximum velocities over Ely, Nev., and Huron, S. Dak. (40.7 and 58.0 m. p. s., respectively), between 2.5 and 5 kilometers, and above 5 kilometers, respectively, were the lowest wind speeds recorded in those levels during the preceding 12 months.

TABLE 1.—*Mean free-air barometric pressures (P.) in mb., temperatures (T.) in ° C., and relative humidities (R. H.) in percent obtained by airplanes during August 1939*

Stations and elevations in meters above sea level	Altitude (meters) m. s. l.																										
	Surface				500			1,000			1,500			2,000			2,500			3,000			4,000			5,000		
	Number of observations	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity	Pressure	Temperature	Relative humidity
Billings, Mont. (1,090 m.)	31	892	17.0	48	----	----	----	----	----	----	851	20.6	39	803	17.4	39	757	13.7	40	712	9.8	42	631	2.1	48	556	−5.3	52
Coco Solo, C. Z.[1] (15 m.)	27	1,009	26.5	92	956	24.6	86	904	22.3	84	853	19.9	83	804	17.8	74	759	15.5	72	715	13.2	64	634	7.8	66	----	----	----
Lakehurst, N. J.[1] (39 m.)	26	1,010	21.4	90	957	22.4	74	904	20.0	71	853	16.9	75	804	14.3	71	758	11.9	66	714	9.1	64	632	4.0	55	559	−1.1	45
Norfolk, Va.[1] (10 m.)	27	1,016	23.0	89	961	23.1	69	907	20.2	70	856	17.1	71	807	14.1	70	760	11.0	66	716	7.9	66	634	2.2	63	559	−3.6	56
Pearl Harbor, T. H.[1] (6 m.)	31	1,014	23.4	77	958	20.5	78	904	16.5	81	853	13.9	77	803	12.1	64	757	11.0	43	713	8.9	32	630	2.3	24	----	----	----
Pensacola, Fla.[1] (13 m.)	26	1,015	22.7	97	960	23.7	69	906	20.5	65	855	17.7	62	806	14.9	59	760	12.2	54	716	9.4	53	634	3.9	50	560	−1.4	47
St. Thomas, V. I.[1] (8 m.)	31	1,016	28.2	76	962	24.2	90	908	21.3	86	857	18.3	82	809	15.7	80	762	13.2	74	718	10.6	66	636	5.3	58	562	−0.2	54
San Diego, Calif.[1] (10 m.)	31	1,011	21.2	81	956	19.0	84	903	24.3	49	852	25.1	33	805	22.6	33	759	19.0	34	716	15.0	37	635	7.0	43	561	−1.2	46
Seattle, Wash.[1] (10 m.)	24	1,016	18.8	65	961	15.8	66	906	16.1	51	855	14.6	45	805	12.8	33	758	10.2	30	713	8.0	28	630	2.1	24	557	−4.6	30
Spokane, Wash. (597 m.)	31	945	16.1	46	----	----	----	902	22.1	34	851	19.2	32	803	15.4	34	757	11.5	36	712	8.3	35	630	1.5	36	556	−5.5	40

[1] Navy.

Observations taken about 4 a. m. 75th meridian time, except by Navy stations along the Pacific coast and Hawaii where they are taken at dawn.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.

TABLE 1a.—*Mean free-air barometric pressures (P.) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by radiosondes during August 1939*

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																							
	Albuquerque, N. Mex. (1,620 m.)				Denver, Colo. (1,616 m.)				Ely, Nev. (1,194 m.)				Nashville, Tenn. (180 m.)				Oakland, Calif. (2 m.)				Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (300 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	31	841	20.2	56	31	841	16.6	58	31	812	13.8	48	31	994	21.1	87	31	1,014	14.7	86	31	968	22.8	74	31	970	19.6	78
500													31	958	22.4	74	31	958	14.5	81	31	956	24.0	67	31	957	20.4	68
1,000													31	904	20.1	73	31	903	21.9	40	31	904	23.2	55	31	904	19.8	60
1,500													31	853	17.1	77	31	853	21.4	28	31	853	21.1	56	31	852	17.6	57
2,000	31	804	19.5	51	31	804	17.9	50	31	804	16.9	44	31	805	14.3	76	31	804	18.8	24	31	805	17.9	59	31	804	15.1	53
2,500	31	759	17.0	50	31	758	15.8	48	31	758	17.7	37	31	758	11.4	71	31	758	16.0	21	31	758	14.5	62	31	757	12.2	54
3,000	31	715	13.6	52	31	715	12.5	46	31	715	14.1	36	31	714	8.8	64	31	714	12.7	20	31	715	11.5	62	31	713	9.3	53
4,000	31	634	5.8	59	31	633	5.2	49	31	633	5.8	39	31	632	3.4	56	31	634	5.8	19	31	634	5.2	62	31	632	2.7	55
5,000	31	561	−1.7	64	31	560	−2.7	54	31	560	−2.7	49	31	558	−2.4	49	31	560	−1.3	19	30	560	−1.9	59	31	557	−3.8	55
6,000	31	494	−8.2	64	31	492	−10.0	56	31	493	−9.9	52	31	491	−8.3	44	31	493	−8.1	19	30	494	−8.1	53	31	490	−9.8	48
7,000	30	433	−14.2	63	31	432	−16.7	51	31	432	−16.0	47	31	432	−14.9	39	31	433	−15.1	19	30	434	−14.2	44	29	430	−16.4	43
8,000	30	379	−21.4	61	30	377	−23.7	48	31	378	−23.1	45	30	377	−21.8	36	31	378	−22.4	18	30	379	−21.2	43	29	376	−24.1	41
9,000	30	330	−29.1	59	30	328	−31.4	48	31	328	−31.1	43	30	329	−29.2	35	31	329	−30.2	17	29	330	−28.5	43	29	327	−31.7	40
10,000	30	287	−36.8	57	29	285	−39.1	46	31	285	−39.0	41	30	285	−36.9	34	31	286	−38.2	17	29	287	−36.3	43	29	283	−39.1	37
11,000	30	248	−44.3	----	29	245	−47.0	----	31	246	−46.7	----	30	246	−44.3	----	31	246	−45.4	----	29	248	−43.8	----	29	244	−46.5	----
12,000	29	213	−52.0	----	29	211	−53.7	----	30	211	−53.1	----	30	212	−51.0	----	31	212	−51.6	----	28	214	−51.1	----	29	210	−52.9	----
13,000	29	182	−59.0	----	29	180	−58.9	----	30	180	−58.4	----	30	181	−56.3	----	31	182	−56.0	----	27	183	−57.6	----	29	179	−57.5	----
14,000	29	154	−64.8	----	27	153	−62.4	----	30	153	−61.6	----	29	155	−60.7	----	31	154	−60.4	----	27	156	−62.7	----	29	153	−60.3	----
15,000	29	131	−69.0	----	26	130	−63.6	----	30	130	−63.9	----	28	131	−64.2	----	30	132	−63.4	----	27	133	−66.0	----	28	130	−62.0	----
16,000	29	111	−70.1	----	25	111	−64.6	----	30	111	−64.0	----	28	112	−65.2	----	30	112	−65.0	----	26	112	−66.6	----	27	111	−61.5	----
17,000	28	94	−67.5	----	24	94	−64.1	----	29	94	−62.7	----	25	95	−65.1	----	29	95	−64.7	----	24	95	−65.8	----	26	94	−60.8	----
18,000	25	80	−64.8	----	22	79	−62.4	----	27	80	−60.9	----	23	80	−64.4	----	27	81	−63.1	----	22	81	−64.0	----	25	80	−59.8	----
19,000	18	67	−62.2	----	16	67	−60.7	----	25	68	−59.9	----	21	68	−62.8	----	23	69	−61.5	----	19	69	−62.2	----	23	68	−58.7	----
20,000	9	57	−59.5	----	12	57	−59.0	----	15	58	−57.7	----	18	58	−60.8	----	20	58	−59.5	----	14	58	−60.5	----	19	58	−57.1	----
21,000	5	48	−57.6	----	8	48	−57.3	----					15	49	−58.7	----	16	50	−57.9	----	6	50	−59.0	----	11	49	−56.1	----
22,000					5	41	−56.3	----					9	42	−57.0	----	11	43	−56.7	----					5	42	−54.8	----
23,000													6	35	−55.0	----	7	37	−55.2	----								

Altitude (meters) m. s. l.	Stations and elevations in meters above sea level																							
	Phoenix, Ariz. (339 m.)				El Paso, Tex. (1,193 m.)				San Juan, P. R. (18 m.)				Washington,[1] D. C. (7 m.)				Atlanta, Ga. (298 m.)				Joliet, Ill. (178 m.)				Miami, Fla. (4 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	30	971	28.6	54	31	882	22.3	57	31	1,013	24.8	88	30	1,014	21.9	87	31	981	21.5	92	31	994	17.1	92	31	1,015	24.0	92
500	30	954	29.8	49					31	959	23.1	87	30	959	21.5	77	31	959	21.8	85	31	958	20.7	72	31	960	24.0	83
1,000	30	902	28.8	43					31	905	20.0	84	30	905	19.0	72	31	906	19.7	82	31	904	18.7	66	31	906	21.4	78
1,500	30	853	25.4	42	31	852	22.9	53	31	854	17.0	80	30	853	15.9	73	31	854	16.6	79	31	852	15.8	65	31	856	18.9	73
2,000	30	805	21.5	45	31	804	20.4	52	31	805	14.7	73	30	804	13.0	69	31	805	13.7	77	31	803	12.8	64	31	807	16.4	72
2,500	30	759	17.8	48	31	758	16.7	54	31	759	12.5	65	30	758	10.2	61	31	759	10.6	75	31	756	10.2	58	31	760	14.2	67
3,000	30	716	14.1	53	31	715	13.0	58	31	715	9.8	61	30	713	7.3	57	31	714	7.7	73	31	712	7.7	50	31	717	11.6	65
4,000	30	635	6.5	59	31	634	5.4	65	31	633	4.4	56	30	631	2.0	56	31	632	1.8	65	31	630	2.0	48	31	636	6.4	60
5,000	30	562	−1.3	66	31	561	−1.3	63	31	560	−1.4	47	30	557	−3.2	57	31	558	−3.4	61	29	556	−4.1	50	31	562	0.8	58
6,000	29	494	−7.1	67	31	494	−6.8	57	31	493	−6.9	42	30	490	−8.8	53	32	491	−9.0	57	29	489	−9.7	48	31	496	−4.9	55
7,000	29	435	−13.1	61	31	434	−12.7	51	31	433	−13.8	42	30	430	−14.7	49	31	431	−15.4	52	29	429	−16.2	45	31	436	−10.9	54
8,000	29	380	−19.5	56	31	380	−19.5	47	31	379	−20.8	42	30	376	−20.9	45	31	377	−22.4	50	28	375	−23.5	43	31	382	−17.4	54
9,000	29	332	−26.9	52	31	332	−26.8	45	31	330	−28.0	42	28	328	−28.0	42	31	328	−29.9	49	28	326	−31.1	42	30	334	−24.4	54
10,000	29	288	−34.9	50	31	288	−34.8	44	31	286	−35.6	41	27	285	−35.5	39	31	284	−37.6	48	27	283	−38.6	----	30	290	−31.9	52
11,000	29	249	−42.7	----	31	249	−42.6	----	31	247	−43.1	----	26	246	−43.3	----	31	245	−44.9	----	26	244	−45.9	----	30	251	−39.7	50
12,000	29	215	−50.2	----	30	214	−50.2	----	31	213	−50.2	----	26	212	−50.6	----	31	211	−51.9	----	26	209	−52.1	----	30	217	−47.3	----
13,000	28	184	−57.2	----	30	183	−57.8	----	31	182	−56.9	----	24	181	−56.1	----	31	180	−58.0	----	23	179	−55.8	----	30	186	−54.6	----
14,000	27	156	−64.2	----	30	156	−64.6	----	31	155	−62.7	----	21	154	−60.8	----	31	153	−63.4	----	22	153	−58.5	----	30	159	−61.1	----
15,000	26	133	−68.6	----	31	132	−70.1	----	31	132	−67.5	----	20	131	−63.8	----	31	130	−66.9	----	21	130	−60.7	----	30	136	−65.9	----
16,000	26	112	−70.0	----	29	112	−72.1	----	30	112	−70.2	----	14	111	−64.4	----	30	110	−68.1	----	18	111	−61.7	----	30	115	−67.9	----
17,000	26	95	−69.0	----	29	94	−70.2	----	28	94	−71.6	----	11	94	−63.4	----	28	93	−66.7	----	17	94	−61.2	----	30	97	−67.9	----
18,000	25	80	−66.8	----	26	80	−66.6	----	27	79	−71.4	----	8	80	−61.4	----	25	79	−64.9	----	14	80	−59.8	----	30	82	−67.2	----
19,000	21	68	−63.9	----	21	68	−63.9	----	23	67	−69.6	----					17	67	−62.6	----	11	68	−57.9	----	28	70	−65.6	----
20,000	18	58	−60.8	----	13	57	−61.5	----	17	57	−67.2	----					7	57	−61.3	----	5	58	−56.7	----	25	59	−64.0	----
21,000	14	49	−58.9	----	8	49	−59.7	----	13	48	−64.7	----													22	50	−62.5	----
22,000	6	42	−57.3	----					8	40	−62.7	----													12	43	−60.6	----
23,000									6	34	−60.8	----													10	36	−59.3	----
24,000																									8	31	−58.3	----

Observations taken about 4 a. m. 75th meridian time.

[1] Navy.

NOTE.—None of the means included in this table are based on less than 15 surface or 5 standard-level observations.
Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels, also, the humidity data are not used in daily observations when the temperature is below −40° C.

TABLE 1B.—*Mean free-air barometric pressures (P) in mb., temperatures (T) in °C., and relative humidities (R. H.) in percent obtained by radiosondes during August 1939*—Continued

LATE REPORTS FOR APRIL AND MAY, 1939

Altitude (meters) m. s. l.	Boston, Mass.[1]								Altitude (meters) m. s. l.	Boston, Mass.[1]							
	April 1939[2]				May 1939					April 1939[2]				May 1939			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	27	1,013	4.4	76	31	1,013	11.1	76	11,000	20	226	−53.5		25	232	−52.4	
500	27	955	2.8	76	31	957	10.6	72	12,000	18	193	−55.4		23	199	−55.5	
1,000	27	898	1.7	71	31	901	9.4	63	13,000	14	165	−56.1		22	170	−56.6	
1,500	27	843	0.5	70	31	848	7.2	61	14,000	13	141	−55.2		22	145	−56.7	
2,000	27	792	−1.4	67	30	798	4.2	61	15,000	12	120	−54.7		22	124	−56.1	
2,500	27	744	−3.3	61	30	750	1.2	61	16,000	11	102	−54.5		19	106	−55.7	
3,000	27	698	−5.4	57	30	705	−1.4	60	17,000	10	87	−53.9		18	91	−55.1	
4,000	26	614	−10.5	52	30	621	−6.9	56	18,000	8	75	−54.4		15	78	−53.9	
5,000	26	538	−15.7	50	30	545	−12.2	48	19,000	6	64	−53.7		14	66	−52.5	
6,000	26	471	−22.7	49	30	478	−18.7	44	20,000	5	54	−53.1		13	57	−51.1	
7,000	25	410	−29.8	49	29	417	−25.6	42	21,000					13	49	−49.2	
8,000	24	356	−37.0	49	29	362	−32.5	42	22,000					10	42	−46.6	
9,000	23	307	−44.0		27	314	−40.3	39	23,000					5	36	−44.2	
10,000	22	264	−50.5		27	270	−47.4										

[1] Operated by Massachusetts Institute of Technology.

[2] Began April 3, 1939.

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (E. S. T.) during August 1939*

[Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—Velocities in meters per second (superior figures indicate number of observations)]

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)		Albuquerque, N. Mex. (1,554 m.)		Atlanta, Ga. (302 m.)		Billings, Mont. (1,095 m.)		Boise, Idaho (850 m.)		Brooklyn, N. Y. (15 m.)		Brownsville, Tex. (7 m.)		Buffalo, N. Y. (220 m.)		Burlington, Vt. (132 m.)		Charleston, S. C. (18 m.)		Cheyenne, Wyo. (1,873 m.)		Chicago, Ill. (192 m.)		Cincinnati, Ohio (157 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	158	2.5[31]	231	1.8[31]	258	0.3[30]	272	0.[31]	293	3.2[31]	163	3.6[30]	128	5.3[30]	260	2.7[31]	243	0.7[31]	167	2.3[31]	9	0.9[31]	228	0.8[31]	180	0.6[31]
500					241	.4[30]					192	1.7[30]	140	6.5[30]	257	3.2[31]	226	1.8[31]	185	3.9[31]			210	1.3[31]	218	.7[31]
1,000	163	3.2[31]			190	1.0[30]			297	3.3[31]	236	2.0[28]	148	5.3[29]	249	3.9[29]	224	3.2[31]	206	3.2[31]			246	3.1[30]	239	1.5[31]
1,500	158	2.8[31]			91	.6[28]	350	.5[31]	302	2.2[31]	266	3.1[27]	150	3.4[27]	241	3.4[29]	231	4.6[31]	228	3.4[29]			264	2.7[28]	261	1.7[30]
2,000	172	2.3[30]	225	2.1[31]	29	1.0[32]	311	1.2[31]	320	1.9[31]	275	4.6[24]	136	2.5[30]	243	3.8[28]	252	6.0[29]	232	3.4[30]	4	.8[31]	282	3.0[28]	272	2.2[28]
2,500	161	1.8[30]	224	1.0[31]	10	1.6[28]	284	3.4[31]	290	2.2[31]	268	5.8[30]	132	2.7[33]	249	4.3[24]	257	5.3[24]	236	4.0[25]	324	.9[31]	296	4.2[27]	273	3.0[28]
3,000	136	1.4[28]	357	.3[31]	352	1.4[29]	280	6.2[30]	268	3.4[31]	263	6.0[17]	136	2.3[23]	251	4.1[30]	263	4.8[18]	234	3.9[28]	298	2.1[30]	307	4.7[24]	292	4.3[26]
4,000	60	1.4[24]	353	1.6[31]	328	2.5[16]	265	8.3[23]	258	6.5[27]	262	5.9[15]	123	1.0[17]	261	6.5[14]	277	6.9[12]	234	4.2[20]	290	5.4[27]	293	6.3[20]	288	4.4[21]
5,000	24	1.7[18]	324	1.9[29]	318	3.3[15]	261	9.4[21]	255	9.0[24]	258	6.0[13]	132	1.6[11]					238	5.6[11]	286	8.4[23]	274	9.1[10]	271	4.6[17]
6,000	5	3.2[17]	310	2.6[23]	300	4.9[13]	265	10.5[20]	248	10.0[22]	269	7.0[10]	126	1.8[10]							296	11.9[14]			270	7.1[19]
8,000	353	3.9[13]	281	4.6[23]			267	12.9[19]	263	9.3[18]											288	16.8[13]				
10,000	320	4.2[13]	274	11.2[18]			261	15.7[16]													289	21.1[11]				
12,000	316	4.9[16]	280	14.1[12]																						

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)		Fargo, N. Dak. (283 m.)		Greensboro, N. Car. (271 m.)		Havre, Mont. (766 m.)		Houston, Tex. (21 m.)		Huron, S. Dak. (393 m.)		Las Vegas, Nev. (570 m.)		Little Rock, Ark. (82 m.)		Medford, Oreg. (410 m.)		Miami, Fla. (10 m.)		Minneapolis, Minn. (261 m.)		Nashville, Tenn. (194 m.)		New Orleans, La. (19 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	194	1.8[31]	225	1.1[31]	239	0.8[29]	263	1.3[28]	186	2.2[31]	211	1.6[31]	185	1.7[31]	204	1.1[31]	315	2.0[31]	109	1.8[30]	253	1.8[30]	338	0.1[30]	237	1.7[31]
500			220	1.8[31]	211	1.0[28]	253	2.4[30]	184	3.3[31]	215	1.7[31]			241	1.0[31]	312	2.3[31]	134	1.8[30]	251	2.2[29]	276	0.4[30]	262	2.9[31]
1,000			250	2.0[30]	244	1.6[28]	258	3.5[26]	198	2.7[31]	213	1.5[31]	183	1.8[31]	270	1.7[31]	314	2.4[31]	162	1.3[29]	239	2.3[29]	247	0.9[30]	280	3.2[30]
1,500	177	1.6[31]	253	3.2[29]	268	2.5[27]	265	4.1[25]	188	1.9[30]	219	1.9[31]	183	2.0[31]	280	2.2[30]	274	1.2[31]	202	1.2[29]	251	2.3[28]	264	1.7[28]	308	3.1[30]
2,000	122	1.6[31]	268	4.5[30]	278	3.4[27]	289	4.8[28]	148	1.3[29]	260	2.6[28]	219	2.6[31]	299	3.2[31]	218	2.1[31]	180	1.3[27]	276	3.0[30]	276	2.7[28]	320	2.9[26]
2,500	90	2.5[31]	281	4.9[28]	273	3.7[29]	265	6.1[26]	122	1.1[30]	285	4.1[27]	236	3.2[31]	309	3.7[30]	205	3.5[31]	180	1.3[27]	300	5.1[29]	286	2.3[29]	326	2.6[29]
3,000	77	2.7[30]	292	5.5[30]	258	3.3[18]	272	9.4[23]	126	1.1[30]	298	5.8[27]	229	3.5[30]	304	4.5[30]	212	5.0[31]	179	1.8[27]	299	6.8[31]	292	2.4[28]	331	2.9[29]
4,000	70	2.5[34]	303	8.4[31]	265	3.3[18]	273	11.0[19]	329	.2[31]	302	7.4[27]	216	3.6[26]	329	5.4[28]	221	6.7[31]	169	2.3[27]	305	7.6[27]	298	2.9[17]	340	3.1[28]
5,000	89	1.8[13]	295	11.3[17]	240	3.4[16]	280	13.0[19]	299	2.0[16]	304	8.7[23]	202	3.7[29]	334	6.4[22]	221	7.6[31]	183	2.3[26]	307	7.1[14]	289	4.7[31]	318	2.7[31]
6,000	182	.7[14]	296	12.4[16]					292	2.5[19]	310	9.9[23]	201	4.3[28]	337	5.6[14]	228	8.0[28]	152	2.5[22]	306	8.7[12]			295	3.1[18]
8,000	218	.3[19]	289	14.4[14]							304	11.7[17]	262	4.8[26]	302	5.0[16]	237	11.1[19]	94	4.5[13]						
10,000			300	16.9[16]							300	12.9[18]	263	9.0[25]												
12,000											299	16.2[11]	262	13.4[22]												
14,000													270	13.1[19]												
16,000													254	6.0[16]												

Altitude (meters) m. s. l.	Oakland, Calif. (8 m.)		Oklahoma City, Okla. (402 m.)		Omaha, Nebr. (306 m.)		Reno, Nev. (1,346 m.)		St. Louis, Mo. (170 m.)		Salt Lake City, Utah (1,294 m.)		San Diego, Calif. (15 m.)		San Juan, P. R. (16 m.)		Sault Ste. Marie, Mich. (198 m.)		Seattle, Wash. (14 m.)		Spokane, Wash. (603 m.)		Washington, D. C. (10 m.)		Winslow, Ariz. (1,488 m.)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°		°	
Surface	276	4.7[31]	188	2.3[31]	172	1.0[31]	266	0.7[31]	202	0.6[31]	305	1.7[31]	226	4.3[30]	83	5.3[31]	267	2.1[30]	285	2.4[31]	237	1.4[31]	205	1.2[31]	318	1.1[31]
500	273	2.9[31]	187	2.7[31]	164	.7[31]			126	.8[31]			294	2.3[30]	99	6.8[31]	271	2.4[30]	293	1.0[31]			215	1.5[31]		
1,000	223	2.4[30]	194	3.0[31]	196	.8[31]			245	.5[31]			292	1.3[30]	108	5.9[30]	253	3.5[28]	221	1.2[29]	234	2.4[31]	238	1.3[30]		
1,500	201	3.1[30]	209	3.6[31]	233	1.3[31]	251	.7[31]	248	1.2[30]	309	1.8[31]	315	1.3[27]	105	5.7[29]	256	3.9[28]	197	2.4[28]	223	2.5[31]	296	1.9[30]		
2,000	185	4.0[29]	224	3.0[30]	269	2.4[31]	206	1.5[31]	264	3.0[27]	310	1.9[31]	287	.5[27]	99	5.5[28]	265	5.7[28]	216	1.6[24]	225	3.7[31]	309	3.0[28]	306	.9[31]
2,500	194	4.7[29]	258	3.0[28]	287	3.6[29]	199	3.0[31]	278	3.8[24]	307	2.2[25]	167	.8[25]	96	5.3[27]	276	7.2[31]	251	1.3[31]	228	4.4[29]	289	4.1[27]	294	1.5[31]
3,000	198	5.4[29]	282	3.1[28]	283	6.6[27]	215	3.8[31]	272	5.4[18]	275	2.9[31]	158	1.8[23]	92	5.1[28]	282	7.2[19]	255	2.4[29]	242	4.9[27]	273	5.0[24]	294	1.2[31]
4,000	198	7.0[30]	300	3.6[30]	289	10.0[24]	220	6.9[30]			273	4.9[23]	135	2.4[24]	77	5.6[23]	278	9.4[17]	268	2.7[19]	259	7.1[24]	266	5.6[17]	244	.2[29]
5,000	207	6.7[27]	332	4.5[29]	294	10.2[23]	216	7.8[30]			278	6.4[25]	156	3.6[30]	81	4.0[29]	290	10.5[18]	269	4.5[18]	250	9.5[30]			242	.7[27]
6,000	221	5.8[24]	321	6.1[31]	295	11.5[19]	227	7.4[27]			277	7.0[19]	174	2.0[17]	100	3.7[17]	286	12.5[18]	285	5.2[15]	240	11.7[18]			161	.3[24]
8,000	233	8.3[19]	315	6.9[17]	299	12.9[14]	239	12.2[23]			286	6.9[11]			188	1.5[13]			296	5.1[13]					288	1.5[19]
10,000			308	6.6[14]	293	16.1[13]	248	17.7[21]																	269	5.7[19]
12,000			302	11.8[13]	292	16.4[10]	263	17.0[16]																	273	10.9[19]
14,000																									276	10.0[17]

TABLE 3.—*Maximum free-air wind velocities (M. P. S.), for different sections of the United States based on pilot balloon observations during August 1939*

Section	Surface to 2,500 meters (m. s. l.)					Between 2,500 and 5,000 meters (m. s. l.)					Above 5,000 meters (m. s. l.)				
	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	29.2	WSW	1,210	9	Buffalo, N. Y.	28.8	W	4,320	9	Albany, N. Y.	42.2	WSW	11,380	29	Syracuse, N. Y.
East-Central [2]	26.0	W	1,070	18	Greensboro, N. C.	22.8	WNW	3,490	7	Cincinnati, Ohio	25.0	SW	11,310	5	Elkins, W. Va.
Southeast [3]	25.7	SSW	2,410	12	Tampa Fla.	36.8	ESE	4,970	13	Birmingham, Ala.	36.6	ESE	5,010	13	Birmingham, Ala.
North-Central [4]	31.0	SSW	1,330	21	Detroit, Mich.	36.6	WSW	4,920	27	Bismarck, N. Dak.	58.0	W	13,740	21	Huron, S. Dak.
Central [5]	40.4	SSW	1,420	10	Wichita, Kans.	30.6	NW	3,990	22	Des Moines, Iowa	41.6	WNW	12,240	6	Omaha, Nebr.
South-Central [6]	24.2	WSW	610	19	Jackson, Miss.	31.2	W	3,190	10	Amarillo, Tex.	33.0	WNW	12,890	21	Oklahoma City, Okla.
Northwest [7]	24.9	W	1,260	11	Pendleton, Oreg.	28.6	SSW	5,000	27	Medford, Oreg.	52.0	SSW	8,140	27	Medford, Oreg.
West-Central [8]	23.6	WSW	1,880	9	Pueblo, Colo.	40.7	SSE	3,980	29	Ely, Nev.	52.4	SSW	9,070	27	Redding, Calif.
Southwest [9]	30.8	NNW	2,250	15	Sandberg, Calif.	24.2	NNW	2,510	15	Sandberg, Calif.	39.0	W	13,620	7	Las Vegas, Nev.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except El Paso), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

TABLE 4.—*Mean altitudes and temperatures of significant points identifiable as tropopauses during April 1939, classified according to the potential temperatures (10-degree intervals between 320° and 409° A.) with which they are identified. (Based on radiosonde observations)*

Potential temperatures, ° A.	Albuquerque, N. Mex.			Bismarck, N. Dak.			Charleston, S. C.			Denver, Colo.			El Paso, Tex.			Ely, Nev.			Miami, Fla.		
	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, ° C.
310–319				2	8.5	−40.5															
320–329				10	9.6	−44.5				1	10.0	−49.0				2	9.2	−38.0			
330–339	2	11.8	−56.5	20	11.0	−51.4	2	10.0	−39.0	11	11.3	−52.0	1	9.8	−38.0	13	10.7	−47.0			
340–349	9	12.6	−58.0	21	12.1	−54.7	17	12.1	−53.5	12	12.0	−53.4	13	12.2	−54.2	15	12.2	−55.9	4	12.4	−54.7
350–359	17	14.1	−66.5	10	13.2	−59.2	19	13.3	−58.2	11	13.8	−63.2	23	14.1	−66.5	12	13.5	−61.5	7	14.1	−58.9
360–369	9	15.0	−69.8	5	14.0	−61.4	13	14.8	−66.1	5	14.4	−62.8	17	15.1	−71.5	7	14.4	−65.3	13	14.8	−66.9
370–379	10	15.8	−71.4	1	14.4	−59.0	9	15.8	−71.2	6	14.8	−64.8	14	15.9	−72.7	8	15.0	−65.8	13	15.5	−68.4
380–389	10	16.0	−69.3	4	15.1	−62.0	3	16.3	−72.3	5	16.2	−67.8	6	16.4	−73.7	10	15.6	−65.7	5	16.2	−67.6
390–399	2	16.7	−69.5	1	16.0	−65.0	5	16.5	−67.0	6	16.4	−67.2	4	16.9	−72.8	6	16.1	−64.8	8	16.7	−68.8
400–409	1	17.1	−70.0	1	16.2	−62.0	1	17.5	−73.0	8	16.6	−64.4	1	17.2	−71.0	1	16.6	−67.0	3	17.0	−69.7
All (weighted means)		14.7	−66.8		11.9	−53.8		13.9	−61.1		13.9	−60.3		14.6	−67.2		13.4	−58.9		15.3	−65.8
Mean potential temperature (weighted), ° A.		365.0			344.7			360.8			359.4			362.8			358.8			372.5	

Potential temperatures °A.	Nashville, Tenn.			Oakland, Calif.			Oklahoma City, Okla.			Omaha, Nebr.			Phoenix, Ariz.			San Antonio, Tex.			Washington, D. C.		
	Number of cases	Mean altitude (km) m. s. l.	Mean temperature °C	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, °C.	Number of cases	Mean altitude (km.) m. s. l.	Mean temperature, °C.
320–329	3	10.3	−50.0	2	10.0	−44.5				2	8.6	−34.0									
330–339	10	11.0	−49.9	10	10.6	−45.5	2	10.8	−46.0	7	10.5	−46.1	3	11.8	−55.7	2	10.4	−41.5	1	11.9	−57.0
340–349	19	12.2	−53.3	17	11.8	−49.8	8	12.2	−54.9	19	12.3	−55.6	5	12.2	−52.6	5	11.9	−50.4	16	11.8	−51.4
350–359	13	12.9	−55.6	8	13.4	−60.2	13	13.7	−62.2	8	13.3	−59.8	13	13.8	−63.3	10	13.9	−65.5	12	13.2	−57.5
360–369	12	14.6	−65.3	10	14.2	−60.7	12	14.5	−65.7	6	14.3	−63.5	15	15.1	−69.7	7	14.7	−67.9	8	14.6	−64.6
370–379	9	15.4	−67.8	8	15.1	−64.4	5	15.2	−67.2	8	14.9	−63.2	8	16.0	−71.0	4	16.1	−74.0	1	14.7	−59.0
380–389	4	15.4	−62.5	7	15.7	−67.0	7	15.8	−67.1	5	15.5	−63.2	4	16.4	−70.2	13	16.4	−71.6	2	14.7	−65.0
390–399	6	16.5	−66.7	10	16.2	−66.3	3	16.3	−65.7	5	15.6	−60.8	4	16.7	−70.5	2	17.2	−74.0	2	16.6	−68.5
400–409	3	16.7	−66.0	5	16.6	−65.8	5	17.0	−67.2	5	16.5	−63.8				3	17.3	−70.3			
All (weighted means)		13.5	−58.6		13.7	−57.9		14.4	−63.0		13.4	−57.7		14.6	−65.9		14.9	−66.3		13.2	−57.4
Mean potential temperature (weighted), °A.		358.5			363.3			366.1			361.4			364.5			369.1			356.3	

RIVERS AND FLOODS

[River and Flood Division, MERRILL BERNARD in charge]

NOTE.—The report for August will be published in a later issue of the REVIEW.—*Editor.*

WEATHER ON THE ATLANTIC AND PACIFIC OCEANS

[The Marine Division, I. R. TANNEHILL in Charge]

NORTH ATLANTIC OCEAN, AUGUST 1939

By H. C. HUNTER

Atmospheric pressure.—The average conditions over the northern regions showed a marked contrast with those of July, the pressure being low during August over most northwestern and north-central areas, and high near the British Isles. Over the southeastern North Atlantic the pressure averaged slightly above normal, but over the southwestern, somewhat below normal. Near the Maritime Provinces and western Newfoundland the average pressure was a little higher than normal.

The extremes of pressure found in vessel reports at hand were 1035.6 and 982.4 millibars (30.58 and 29.01 inches, respectively.) The higher reading was noted on the Dutch motorship *Barendrecht* near 43° N., 25° W., during the forenoon of the 3d. The lower reading was recorded on the American liner *President Roosevelt*, about 6 p. m. of the 30th, near 50° N., 30° W. The lowest barometer readings noted in connection with the tropical disturbance were not nearly so low as this.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, August 1939*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Julianehaab, Greenland	1,005.0	−4.8	1,018	26	992	14
Reykjavik, Iceland	1,006.7	−2.8	1,031	26	994	14
Lerwick, Shetland Islands	1,015.8	+6.7	1,026	28	994	10
Valencia, Ireland	1,017.1	+3.9	1,028	15, 16	1,003	31
Lisbon, Portugal [1]	1,017.8	+1.2	1,021	11	1,011	4
Madeira [1]	1,018.3	+1.4	1,025	22	1,011	12
Horta, Azores	1,023.1	+0.4	1,030	2	1,010	26
Belle Isle, Newfoundland	1,012.7	+0.5	1,027	25	992	2
Halifax, Nova Scotia	1,016.9	+0.6	1,027	12	1,003	1
Nantucket	1,018.6	0.0	1,027	12	1,007	30
Hatteras	1,015.2	−0.7	1,024	12	1,007	28
Bermuda	1,017.8	−2.9	1,023	12	1,011	17
Turks Island	1,016.5	−1.8	1,019	1	1,009	9
Key West	1,018.3	+0.1	1,021	1	1,012	11
New Orleans	1,014.7	−0.5	1,021	1	1,007	17

[1] For 25 days at Lisbon, 21 days at Madeira.

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket and New Orleans, which are 24-hour corrected means.

Cyclones and gales of the main North Atlantic.—The North Atlantic to northward of the 30th parallel was hardly affected by any cyclonic activity before the middle of August. However, on the 18th a LOW which had been perceptible, but not energetic, for several days near Bermuda, gained considerably in strength as it moved toward the north-northeast, and was noted by the American liner *Steel Scientist*, which encountered a whole gale from the northeast. The storm center was near 40° N., 59° W., at sunset on the 18th, and continued its course to pass close to southeastern Newfoundland late the following day, though by this time it was less vigorous. It seems not to have gained strength again as it moved farther beyond the chief trans-Atlantic steamship lanes.

About 10 days later there was an even more marked development. Pressure had been somewhat lower than the regional average for a few days in an area to northward of the western Azores, and on the 29th the LOW was well formed and advancing northeastward, the location of the center during the evening of that day being about 50° N., 34° W. During the following morning the American steamship *Black Gull*, west-bound, met wind of force 11, the month's lone instance of greater force than 10 that has yet been reported from the North Atlantic.

The storm continued toward the northeast, but had lost strength to some extent before the month closed, when the center was well to westward of Ireland.

Tropical disturbance.—A tropical storm of moderate importance is described elsewhere in this issue of the Review. On the 8th it was located not far from Puerto Rico, whence it moved toward the west-northwest, crossing the Florida Peninsula and the extreme northeastern Gulf of Mexico and then turning northward into Alabama. Damage was but moderate, and over the waters affected the winds connected with the storm seem to have caused but one death, which occurred near shore by the upsetting of a small boat.

Chart XIII shows the path of this storm's center, and indicates the situation on the morning of the 12th.

Fog.—There was a marked decrease in frequency of fog over nearly all North Atlantic areas where it had been met in July. The chief exception was the portion just to eastward of New England.

Near the American coast southward about as far as Delaware Bay and especially just to southward of Long Island, some fog was reported, mainly about the 21st. In decided contrast, the 5° square lying to eastward and northeastward of Cape Cod, 40° to 45° N., 65° to 70° W., had much fog, the list showing 20 days, a considerably larger number than for any other North Atlantic area. There was but little fog in this vicinity before the 5th or after the 26th. The fogginess in this square was considerably more than the average indicated by other Augusts.

In the square next to eastward and southeastward of Sable Island fog was noted on only 2 days, a decidedly small number for this vicinity in late summer.

Near the southern tip of the Grand Banks the square 40° to 45° N., 45° to 50° W. furnished reports of fog on 14 days, again a somewhat greater number than is usual in August. There was but little fog there after the 19th. To eastward of the 45th meridian reports indicate no square with fog on more than 4 days, also no fog anywhere to southward of the 45th parallel except a very little close to the coasts of the Iberian peninsula and northwestern Africa.

Icebergs.—Over part of the Grand Banks of Newfoundland icebergs were noted during August, even a few after the middle of the month; whereas in most years none is seen near the chief steamship lanes after the middle of July. The British freight steamship *Beaverhill*, Quebec to London, hit an iceberg early on the 7th, but was not damaged enough to interfere seriously with the voyage.

OCEAN GALES AND STORMS, AUGUST 1939

Vessel	Voyage		Position at time of lowest barometer		Gale began August	Time of lowest barometer, August	Gale ended August	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Millibars*					
Nerissa, Br. S. S.	St. Thomas	New York	20 50 N.	66 08 W.	8	5a, 8	8	1,014.6	ENE.	ENE, 5	ESE.	ENE, 6	ENE-ESE.
Bruxelles, Belg. S. S.	Antwerp	Havana	46 36 N.	9 06 W.		11a, 8	8	1,018.0		NNW, 9		NNW, 9	
Gulfwing, Am. M. S.	Philadelphia	Las Piedras	24 00 N.	69 45 W.	9	2p, 9	9	1,010.2	E.	ESE, 8	SE.	ESE, 8	E-SE.
Poseidon, Du. S. S.	Curacao	New York	24 53 N.	74 20 W.	10	4a, 10	10	1,008.9	ENE.	ENE, 6	ESE.	ENE, 8	None.
Flora, Du. S. S.	Pto Cabello	do	23 30 N.	74 00 W.	10	8a, 10	11	1,010.0	S.	SW, 4	ESE.	E, 9	NE-SW-SSE.
Cities Service Koolmotor, Am. S. S.	Philadelphia	Port Arthur	28 18 N.	78 42 W.	11	2p, 11	11	1,010.2	E.	E, 7	E.	E, 8	None.
El Estero, Am. S. S.	Galveston	Norfolk	27 30 N.	79 50 W.	11	4p, 11	11	1,001.0	NNE.	NNE, 9	ESE.	NNE, 9	NNE-ESE.
Good Gulf, Belg. M. S.	Antwerp	Port Arthur	32 07 N.	62 17 W.	15	11a, 15	15	1,013.5	SE.	S, 8	W.	S, 8	SE-SW.
Steel Scientist, Am. S. S.	Gibraltar	Boston	40 30 N.	61 00 W.	18	2p, 18	18	999.7	SSE.	NE, 10	N.	NE, 10	ENE-N.
Arundo, Du. S. S.	Wabana	Rotterdam	49 13 N.	44 52 W.	21	Noon, 21	21	[1] 999.9		W, 8		W, 8	W-NW.
Den Haag, Du. M. S.	Baytown, Tex.	do	[2] 46 43 N.	35 50 W.	25	2a, 27	27	1,009.2	NW.	N, 7	NW.	NW, 8	
American Banker, Am. S. S.	London	New York	47 40 N.	34 05 W.	29	4a, 30	31	985.4	ESE.	W, 10	N.	NW, 10	WSW-NW
Gulftide, Am. S. S.	Port Arthur	do	39 45 N.	73 42 W.	29	4a, 30	30	1,002.4	NE.	NE, 8	NE.	NE, 8	
W. C. Fairbanks, Am. S. S.	New Orleans	do	39 56 N.	73 52 W.	28	4a, 30	30	1,004.7	NE.	NE, 8	NNE.	NE, 9	
Black Gull, Am. S. S.	Rotterdam	do	47 39 N.	34 04 W.	29	5a, 30	30	983.4	SE.	WNW, 9	WNW.	WNW, 11	WSW-WNW.
Gulf of Venezuela, Am. M. S.	Port Arthur	do	38 18 N.	74 30 W.	30	7a, 30	30	1,007.8		NW, 8	NNW.	NW, 8	WNW-NNW.
Emile Francqui, Belg. S. S.	Antwerp	do	49 24 N.	24 30 W.	31	10a, 30	31	987.8		SSW, 4		WNW, 8	SSW-W.
City of Alma, Am. S. S.	Bremen	Tampa	45 12 N.	24 18 W.	30	4p, 30	31	998.3	W.	W, 9	WNW.	W, 9	WSW-WNW.
Black Gull, Am. S. S.	Rotterdam	New York	46 00 N.	39 54 W.	31	5p, 31	31	1,002.7	WSW.	W, 9	NW.	W, 9	WSW-NW.
NORTH PACIFIC OCEAN													
Nonsuco, Phil. M. S.	Los Angeles	Manila	18 54 N.	127 00 E.	1	5a, 1	2	994.2	SW.	SW, 7	SW.	SW, 7	
Toorak, Br. S. S.	do	Hong Kong	26 50 N.	154 16 E.	2	2a, 4	4	984.4	ESE.	SE, 10	S.	ESE, 11	SE-E-ESE.
Manoeran, Du. M. S.	Cebu, P. I.	Los Angeles	29 45 N.	148 48 E.	4	3p, 4	4	950.4	ENE.	N, 11	SSE.	W, 11	NE-N-W.
San Clemente Maru, Jap. M. S.	Los Angeles	Yokohama	47 00 N.	176 30 W.	4	Mdt., 3	5	1004.1	W.	WSW, 5	WNW.	W, 8	WSW-W.
Geflon, Nor. M. S.	Estero Bay	do	35 19 N.	144 37 E.	5	6a, 5	5	978.3	ESE.	ESE, 10	S.	SE, 11	E-SSE.
Chirikof, Am. S. S.	Naknek, Alaska.	San Francisco	53 17 N.	158 27 W.	8	8a, 8	8	992.2	N.	N, 8	W.	WNW, 8	NNE-NW.
Capella, U. S. N.	Seward	Dutch Harbor	57 58 N.	149 55 W.	8	11p, 8	9	993.2	ESE.	SE, 8	S.	SE, 8	ESE-S.
Steelmaker, Am. S. S.	Saigon	Hilo	25 12 N.	128 06 E.	11	1a, 12	13	995.9	NE.	SE, 8	E.	SE, 9	NE-SE-ESE.
Cingalese Prince, Br. M. S.	San Francisco	Manila	26 20 N.	157 30 E.	13	4a, 14	14	978.3	SE.	SSW, 9	WSW.	SSW, 9	SSE-W.
Robin Hood, Am. S. S.	Shanghai	Honolulu	29 18 N.	154 16 E.	14	1p, 14	15	986 5	NNW.	SW, 8	SSE.	SSW, 9	WSW-SSW.
Meigs, U. S. A. T.	Manila	San Francisco	35 41 N.	153 20 E.	14	Noon, 15	15	985.8	ENE.	SE, 10	S.	SE, 10	ESE-S.
Potter, Am. M. S.	Hong Kong	Los Angeles	39 30 N.	152 50 E.	14	6p, 15	16	988.2	ENE.	SE, 9	S.	SE, 9	E-S.
R. J. Hanna, Am. S. S.	El Segundo	Portland, Oreg.	42 24 N.	124 42 W.	17	4p, 17	17	1015.2		N, 8	N.	N, 8	NW-N.
Nonsuco, Phil. M. S.	Victorias, P. I.	Los Angeles	10 14 N.	134 14 E.	23	2p, 24	25	996.6	W.	SW, 7	SW.	SW, 7	WSW-SW.
Brajara, Nor. M. S.	Los Angeles	Balboa	17 42 N.	103 36 W.		8a, 31		1003.3		ESE, 8		ESE, 8	

[1] Barometer uncorrected.
[2] Position approximate.

NORTH PACIFIC OCEAN, AUGUST 1939

By WILLIS E. HURD

Atmospheric pressure.—Throughout the Aleutian region, the average pressure in August 1939 was unusually low for the month and more nearly approached the normal for March than that of midsummer. At Dutch Harbor the average barometer, 1,006.4 millibars (29.72 inches), was 4.8 millibars (0.14 inch) below the normal. Along the American coast from Juneau southward, and at the stations at Honolulu and on Midway Island, there were no marked pressure departures, but in the southwestern part of the ocean the average barometer was depressed to an unusual degree, especially at Guam, where the average for the month, 1,004.7 millibars (29.67 inches), was 5.1 millibars (0.15 inch) below the normal for August.

Extratropical cyclones and gales.—A number of LOWS crossed upper latitudes of the ocean during August, but all were of mild to moderate intensity and only two, so far as ships' reports indicate, caused gales of more than moderate force. Both of these disturbances came from Siberia and spent most of their oceanic existence, so far as their centers were concerned, in the Bering Sea.

The earlier appeared east of Kamchatka on the 3d, and on the 4th its center was near St. Paul Island. Thereafter, until the 7th, it oscillated over the eastern part of the Bering Sea. On the 8th it moved rapidly southeastward to near 50° N., 160° W., then as rapidly northward into Alaska. During most of its course it affected the weather along the central waters of the northern routes, but caused gales of force as high as 8 only on the 5th and 8th. That of the 5th was experienced by the Japanese motorship *San Clemente Maru* in 47° N., 176½° W. On the 8th the American steamer *Chirikof* had a gale near 53° N., 158° W., and the U. S. S. *Capella* reported a further gale to the eastward of Kodiak. A low-pressure reading, 992.2 millibars (29.30 inches) was observed on the *Chirikof*.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, August 1939, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Point Barrow	1,010.7	−1.5	1,017	26	1,001	11
Dutch Harbor	1,006.4	−4.8	1,022	12	984	18
St. Paul	1,008.5	−3.4	1,024	24	990	6, 7
Kodiak	1,008.0	−3.2	1,019	25	990	9
Juneau	1,016.6	0.0	1,030	6	1,004	3
Tatoosh Island	1,017.6	+1.7	1,025	17	1,009	9
San Francisco	1,014.0	+0.8	1,020	30	1,007	17
Mazatlan	1,011.1	+0.6	1,015	2	1,009	23, 25
Honolulu	1,014.9	−1.4	1,019	3	1,012	23
Midway Island	1,018.0	−0.6	1,025	3, 4	1,006	29
Guam	1,004.7	−5.1	1,012	6	997	30
Manila	1,004.3	−2.8	1,008	8, 9, 31	1,000	19, 25, 26
Hong Kong	1,002.0	−2.4	1,005.4	8, 21	997.6	16
Naha	1,002.7	−2.7	1,009	10, 22	979	27
Titijima	1,006.1	−1.7	1,013	18, 22	990	1
Petropavlovsk	1,007.6		1,022	18	996	27

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

The later of the two disturbances, after crossing the Bering Sea during the 15th and 16th, was centered on the 17th and 18th over the eastern Aleutians, with lowest pressure, 984 millibars (29.06 inches) at Dutch Harbor on the 18th. This cyclone was locally stormiest on the 17th, when gales of force 8 to 9 occurred within the small region near 53°–54° N., 161°–162° W., according to radio reports received from two ships. The storm during the 19th again traversed the Bering Sea on its way to the Arctic Ocean.

During the 16th to 18th strong northerly winds occurred off the California coast along the eastern slope of an oceanic HIGH. The highest velocity reported by a ship was of force 8 on the 17th.

Tropical cyclones.—A number of tropical disturbances, including typhoons and depressions, occurred in the Far East during August, and contributed to the remarkably low average barometer for the month observed at Guam, Manila, and Naha, as shown in table 1. Two of these cyclones, which originated late in July, were described by the Rev. Bernard F. Doucette, S. J., Manila, P. I., in his report in the July issue of the REVIEW. One of the storms, it may be added, that of July 28 to August 8, attained great violence on August 4–5 between 25° N., 155° E. and 36° N., 144° E., while moving northwestward toward Japan, as shown by the reports of the following vessels: British steamer *Toorak*, 4th, near 27° N., 154° E., maximum wind from the east-southeast, force 11, lowest barometer 984.4 millibars (29.07 inches); Dutch motorship *Manoeran*, 4th, near 30° N., 149° E., maximum wind from north and west, force 11, with hurricane gusts, lowest barometer 959 millibars (28.33 inches); Norwegian motorship *Gefion*, 5th, near 35° N., 145° E., maximum wind from southeast, force 11, lowest barometer 978.3 millibars (28.89 inches).

On August 12 the American steamer *Steelmaker* encountered a southeast gale of force 9, lowest barometer 995.9 millibars (29.41 inches), near 25° N., 128° E., in connection with a cyclone of which we have almost no information, but which will undoubtedly receive ample notice in the August report from Manila.

On the 10th of the month a LOW appeared to the eastward of Guam. As it moved northward it deepened, and on the 14th the British motorship *Cingalese Prince*, in 26°20′ N., 157°30′ E., had a low barometer of 978.3 millibars (28.89 inches), with a south-southwest gale of force 9. Later, on the 14th the American steamer *Robin Hood* had a similar gale, but with higher barometer, near 29° N., 154° E. This typhooon then appeared to be advancing in an almost due north direction, and on the 15th the United States Army transport *Meigs*, near 36° N., 153° E., met a southeast gale of force 10, barometer 985.8 millibars (29.11 inches). A few hours later the American motorship *Potter* had a southeast gale of force 9 about 200 miles farther northward. The typhoon was subsequently lost to observation.

On August 20 a deep depression lay over the Marianas. It took a generally northwest course, passing to the eastward of Naha, Nansei Islands, on the 27th, and entering the Yellow Sea on the 30th. At Naha our a. m. map of the 27th shows the island to have had a north gale of force 8, while the p. m. map shows a low barometer of 979 millibars (28.91 inches). At coastal stations of the Yellow Sea violent gales occurred on the 30th, accompanied by pressure readings below 982 millibars (29.00 inches).

In the American Tropics there were no disturbed conditions until the 31st, when a small depression was entered by the Norwegian motorship *Brajara* during the early morning. The ship had an east-southeast gale of force 8, barometer 1,003.3 millibars (29.63 inches), at 5 a. m., in 17°42′ N., 103°36′ W.

Fog.—Fog continued frequent in August, as in the previous July, along a great stretch of the northern routes, north of the fortieth parallel, particularly between longitudes 155° E. and 150° W., where it occurred on 20 to 35 percent or more of the days, scattered throughout the month. Fog was reported near the Alaska Peninsula on 5 days; off the Washington coast on 10 days; off Oregon on 13 days; off California on 16 days; and off Lower California on 2 days. West of Costa Rica fog was observed on the 29th and 30th.

TYPHOONS AND DEPRESSIONS OVER THE FAR EAST

By BERNARD F. DOUCETTE, S. J.

[Weather Bureau, Manila, P. I.]

Depression, August 3–6, 1939.—First appearing during the afternoon of August 3, this depression moved northeast from a position about 120 miles south of Hong Kong to the central portion of the Formosa Channel east-southeast of Amoy. It then shifted its course to the northwest, moving about 150 miles, and then inclined to the north-northeast, passing close to and northwest of Shanghai. It disappeared over the Yellow Sea, apparently of mild intensity during its short career.

Typhoon, August 7–15, 1939.—A depression very likely originating east of the Mariana Islands first made its appearance on the weather map of August 7 about 300 miles north-northeast of Guam. A westerly movement of about 700 miles during the next three days preceded an inclination to the west-northwest and an intensification to typhoon strength. On August 11, the typhoon was central about 600 miles east-by-north of Aparri, from which location it moved first northwest, then west-northwest, thus crossing Formosa (August 13) and entering China (August 14) a short distance north of Amoy. No trace of the disturbance was found on the afternoon map of August 15.

Depression, August 12–18, 1939.—A depression, apparently of mild intensity, formed far to the east-northeast of Guam and moved in a westerly direction over the ocean until it reached the region about 450 miles east of Aparri where it inclined to the north. For about 120 miles it moved in this direction, and then made a sharp turn to the east, disappearing August 18.

Depression, August 16–20, 1939.—A mild depression, as far as can be determined from available information, formed about 300 miles northwest of Guam. It moved in a northeasterly direction, then inclined to the north when it reached the 145th meridian. It did not proceed very far along this course before it gradually changed its direction to the west-northwest, passing about 100 miles south of the Bonins. It disappeared over the ocean regions east of the Nansei (Loochoo) Islands.

Observations from ships were adequate to provide complete data on all these disturbances. The typhoon especially was well located, and its intensity definitely known from observations received from the United States Army transport *Meigs*, and the steamships *Pres. Van Buren*, *Washington*, *Adrastus*, and *Marchen*. Pressure values reported showed that there certainly was a typhoon, yet the winds were not strong and dangerous. The center probably was small and could not exert its influence over long distances.

Up to August 18 very little power was manifested in the upper winds over the regions of the Far East. Over

Guam, southwest and west winds predominated with velocities less than 40 k. p. h. except on August 15 and 16. The winds over the Philippines were from the southwest quadrant, with tendencies to shift to the west and even west-northwest at times. Velocities were, as a rule, below 40 k. p. h., with 50 k. p. h. being reported once in a while and then only in isolated groups of the pilot code. On the other hand, Thailand and southern Indo-China stations often reported winds over their regions steadily maintaining velocities of 50 k. p. h. and more. This strength was not evident over the Philippines at any time. The stations of the Netherlands East Indies had east quadrant winds, except Tarakan and Menado, which changed to the west and southwest quadrants on various days. Medan, however, seemed to be in the same air stream that was flowing over Thailand. In general, a quiet situation persisted during this part of the month.

Depression, August 18–22, 1939.—A depression formed about 180 miles west-by-north of Guam and moved westerly, gradually inclining to the west-northwest. It vanished when about 350 miles east of northern Luzon. This depression seemed to be of minor importance.

Typhoon, August 21–September 2, 1939.—The first indication of the existence of this storm came with the Guam observations of August 21, the falling pressure and the northerly winds showing the approach of a disturbance. Very likely it had formed over the Eastern Caroline Islands before August 21 and was undoubtedly moving along a northwesterly course toward Guam. During the afternoon and evening of this same day, it passed about 100 miles north of Guam, at the same time inclining to the southwest, following the latter course for 180 miles, more or less. The morning of August 22 showed the center to be about 150 miles west by south of Guam, starting a west-northwest course toward the Philippines. There was no doubt during these days, August 22 to 25, that it was a severe and intense typhoon, exerting its influence far from the center. Until August 25 it threatened northern Luzon, but fortunately for the whole archipelago, it recurved to the northeast when about 360 miles east by south of Aparri. For a day it proceeded along this northeasterly course and then inclined to the north-northwest when it reached the neighborhood of latitude 21°30′ N., longitude 132° E. August 27 and 28 it moved along this course and then changed to the northwest on August 29, a course which it followed across the Eastern Sea after it had passed close to and south of Borodino Island and then about 150 miles north of Naha Island. An inclination to the north-northwest as the center approached China caused the storm to pass about 80 miles to the northeast of Shanghai, after which the storm gradually weakened. Approaching Shantung Peninsula along a north-northwest course, the typhoon passed over land for the first time in its career, on August 31, moving inland about 50 miles north of Tsingtao. A change to the west on September 1 carried the center well into the continent, where it finally disappeared on September 2.

There is no doubt that this typhoon is to be considered as one of the major storms occurring over these regions and it is very fortunate that practically its whole course was over the ocean regions, far from populated centers. The following data will show the reader the magnitude and intensity of this typhoon. Soon after the center passed Guam, it caused the pressure at Yap to fall, the lowest value reported during these days being 749.8 mm. (999.7 mb) with southwest winds, force 6. There were many ships sending observations, those from the steamships *Bengalen, Nonsuco, Sagoland, Steel Trader, and Steel Navigator* deserving special mention, as they helped very much in locating the typhoon center. The first important series of observations, however, came from the S. S. *John A. Brown*, which was traveling along a westerly course toward San Bernardino Strait while the typhoon center moved west-northwest, passing North of the ship's course. The S. S. *John* A. *Brown* had north quadrant winds, backing to the southwest and increasing to force 9 and 11. The lowest pressure reported during the series of observations sent to Manila was 746.0 mm. (994.6 mb) with west-southwest winds, force 9, from latitude 13.0° N., longitude 132.0° E. (August 24, 8 a. m.). About this time, the second important series of observations began to arrive from the S. S. *Deroche*, traveling along a northeasterly course from the locality of the Balintang Channel. These observations showed definitely that the typhoon was recurving and the series is given below in some detail. August 24, 3 p. m., lat. 20.7° N., long. 126.3° E., pressure 750.8 mm. (1,001.0 mb) with winds north-northeast, force 6. August 25, 8 a. m., lat. 22.0° N., long. 128.5° E., pressure 749.3 mm. (999.0 mb) winds northeast, force 7. August 25, 2 p. m., lat. 21.8° N., long. 129.3° E., pressure 746.3 mm. (995.0 mb), winds north-northeast, force 7. August 26, 6 a. m., lat. 21.2° N., long. 131.3° E., pressure 741.7 mm. (988.8 mb), winds northwest, force 7. August 26, 3 p. m., lat. 21.3° N., long. 132.6° E., pressure 736.2 mm. (981.5 mb) winds west, force 7. At this time the center began to move in a northwesterly direction and Borodino Island felt its effect the next morning, August 27, 5 a. m., when a pressure of 716.3 mm. (955.0 mb), with northeast winds, force 7, was reported. At 6 a. m. August 30, when the typhoon center was approximately 60 miles northeast of Shanghai, a pressure value of 738.9 mm. (985.1 mb), with northwest winds, force 7, was reported from that city. Tsingtao, on August 31, 6 a. m., with the typhoon center approaching the locality from the southeast, reported a pressure of 730.3 mm. (973.7 mb) with north-northeast winds, force 9. The U. S. S. *Chaumont*, located at lat. 28.5° N., long. 119.3°, E. or nearby, made observations almost every hour during the day and evening. The winds were north-northeast, force 10, veering to northeast and east and weakening late in the afternoon. The lowest pressure reported was 995 mb (746.3 mm.) at 0400 G. M. T. (noon, local time). These observations show the shift of movement to the west.

The upper winds during these days had many characteristics of interest. The pilot balloon data from Guam preceding August 20 showed southeast quadrant winds, under 40 k. p. h. August 21, a mild northerly current was flowing, velocities under 40 k. p. h., changing during the afternoon hours to the west-northwest, west, and west-southwest, with the velocities increasing to values slightly over 50 k. p. h. The next day, (22d), however there was a strong southeasterly current with velocities from 30 to 80 k. p. h., the first indication of the strength of the typhoon. The U. S. S. *Gold Star* was approaching Guam from the north, traveling along the 142d and 143d meridians. There were a few short ascents reported from this vessel when traveling between lats. 24° and 18° N., which showed the presence of an easterly current, with velocities at these lower levels less than 40 k. p. h. There was a powerful easterly current, however, which affected Aparri and changed the air stream over that station from the southwest quadrant to the east quadrant. The velocities at Aparri were not strong, but there were some long ascents during the period from August 19 to 22, which showed the height of this easterly current to be

about 7,000 meters. Menado, Netherlands East Indies, gave early indications of the strength of the typhoon. On August 17 weak variable winds were reported over this station; August 18, northwest and west quadrant winds, with velocities up to 40 k. p. h. (which are quite strong for Menado). No data were received August 19 and 20. On August 21 and the following days, west and southwest quadrant winds were continually blowing, with velocities from 15 to 60 k. p. h. Every ascent reported had at least one group with velocities of 50 k. p. h. or more. Menado pilot balloon data were excellent in giving advance notice of the violence of this typhoon. Over the Philippines, after August 22, a very strong southwest quadrant current was flowing. Thailand and southern Indo-China should be included with the Philippines, being under the influence of the same air stream. Cebu reported the strongest velocities from the Archipelago, having velocities 90 k. p. h. and 100 k. p. h. and over, twice. Thailand stations regularly had velocities between 50 and 90 k. p. h. with values over 100 k. p. h. reported a few times. This current extended to Guam and even to Wake Island, where it changed to the southwest quadrant August 29. The southern extent of this powerful current was approximately the latitude of Batavia, where east quadrant winds prevailed during these days. These details indicate the tremendous activity which accompanied this storm. After the center passed Shanghai, the only pilot runs reported were from the U. S. S. *Augusta*, where one ascent was made on September 1, after the typhoon had crossed Shantung Peninsula. The ship was at lat. 36.0° N., long. 120.8° E. and the upper winds up to 500 meters were from the south, velocities 44 to 62 k. p. h. (September 1, 1000 G. M. T.).

Scarcely anything is to be mentioned concerning loss of life and property damage. The newspapers of Manila had dispatches of the loss of two lives in Shanghai, and that seems to be the only information available. It is possible that there were heavy rains over China due to this typhoon, thereby causing floods, but no reports were received. It is very fortunate that the typhoon center kept away from populated regions almost throughout its course.

Typhoon, August 22–24, 1939.—First appearing as a depression central about 180 miles west-northwest of Aparri, this storm moved west, then west-northwest, intensifying to typhoon strength when about 200 miles south of Hong Kong. From this position, it moved rapidly west, across the Gulf of Tong King into the Continent where it soon disappeared. Winds of force 7 with pressure values close to 749.5 mm. (999.2 mb) were reported from stations around the Gulf of Tong King, August 24, 6 a. m., the wind directions showing that the center was close to the coast of Indochina.

MEAN MONTHLY ISENTROPIC CHART

The mean isentropic chart (chart XII) for August 1939, θ=315°, is characterized by a significant departure from the pattern which is regarded as normal for August (see Wexler and Namias, Mean Monthly Isentropic Charts and Their Relation to Departures of Summer Rainfall, Trans. Amer. Geophys. Union, 1938, Part I). There is a definite eastward displacement of the moist and dry tongues over the eastern part of the country.

The dry tongue, which usually is observed entering the country over Lake Michigan, is seen to enter over Lakes Erie and Ontario, and may be associated with the drought over the Northeastern States, the Ohio Valley, and Tennessee. Its extension into Louisiana and eastern Texas corresponds roughly to the subnormal precipitation there. The moist tongue usually observed over the Southeastern States is displaced off the coast, and is correlated with the excess of precipitation to its left, covering the Middle and South Atlantic Coast. The large excess of precipitation over Alabama and Georgia, however, is not to be associated with any circulation pattern to be seen on the mean chart, since it is due to the tropical storm which moved inland and remained almost stationary over those states for 5 days. The effect of this storm on the mean circulation for the entire month would not be noticeable, while its influence on the precipitation departures is dominant in that area.

The displacement eastward of the dry tongue permitted the southwestern moist tongue to evidence upslope motion over the middle Mississippi Valley in the average picture, with consequent positive departures from the normal precipitation there.

(NOTE.—In chart XII, the red and black arrows, introduced this month, are to be considered not as actual trajectories, but rather as identifying the axes of the moist and dry tongues.)

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

TABLE 1.—*Condensed climatological summary of temperature and precipitation by sections, August 1939*

[For description of tables and charts, see REVIEW, January, p. 31]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	78.6	−1.1	Centerville	99	10	Oneonta	53	27	10.59	+6.06	Geneva	23.73	Waterloo	1.63
Arizona	79.2	+.7	3 stations	114	[1] 12	Big Springs	37	26	2.38	+.04	Nogales	7.01	Fredonia	.01
Arkansas	80.2	+.1	Texarkana	107	[1] 17	Lead Hill	49	21	2.50	−1.03	Mount Ida	6.84	Index	.27
California	73.2	+.8	Cow Creek	122	17	2 stations	24	[1] 30	.07	−.03	Seven Oaks	1.66	111 stations	.00
Colorado	66.5	+.9	2 stations	103	[1] 5	Pearl	18	21	1.08	−.86	Westcliffe	4.75	2 stations	T
Florida	80.1	−1.3	Raeford	99	22	2 stations	60	[1] 17	10.78	+3.71	De Funiak Springs	25.18	Daytona Beach	3.00
Georgia	78.3	−1.2	Stillmore	104	10	Blairsville	48	31	7.09	+1.84	Fort Gaines	15.51	Fairmont	3.84
Idaho	67.7	+1.3	Lewiston	107	11	Big Creek	22	7	.16	−.48	American Falls	.97	10 stations	.00
Illinois	73.5	−1.0	2 stations	99	[1] 15	2 stations	48	[1] 23	4.74	+1.38	New Boston	11.97	Golconda	1.10
Indiana	73.8	+.3	do	99	[1] 11	Marengo	46	22	2.65	−.71	Goshen	7.45	Kokoma	.78
Iowa	70.7	−1.5	Thurman	99	30	Sibley	38	21	4.72	+1.15	Ottumwa	9.16	Little Sioux	1.37
Kansas	78.1	+.2	Wellington	112	30	Oberlin	45	21	3.50	+.40	Lyons	9.40	Richfield	T
Kentucky	75.3	−.5	Henderson	99	13	Middlesboro	43	23	2.88	−.91	La Grange	6.98	Oneonta	.72
Louisiana	82.0	+.1	Calhoun	105	17	St. Joseph	58	29	4.86	−.22	Paradis (near)	11.13	Urania	1.03
Maryland-Delaware	76.3	+3.0	College Park, Md	99	9	2 stations	44	[1] 5	5.03	+.44	Dover, Del	16.08	Chewsville, Md	.64
Michigan	68.4	+2.4	3 stations	95	[1] 1	Watersmeet	35	22	4.48	+1.79	Gull Lake (near)	9.13	Ann Arbor	.76
Minnesota	68.8	+1.2	Wadena	99	5	Mizpah	36	21	3.88	+.69	Two Harbors	10.86	Fergus Falls	1.41
Mississippi	80.6	−.2	2 stations	100	11	Holly Springs	55	28	2.83	−1.39	Merrill	8.15	Stoneville	.61
Missouri	75.4	−1.1	Caruthersville	106	14	Greenville	45	22	4.80	+1.00	Monroe City	13.04	Owensville	1.26
Montana	66.2	+1.2	2 stations	103	[1] 3	Summit	19	7	.62	−.46	Savage	2.27	Heron	T
Nebraska	73.5	+.3	Alma	106	29	2 stations	36	[1] 8	2.04	−.69	Pawnee City	5.45	Dalton	.25
Nevada	73.3	+2.7	Overton	117	13	San Jacinto	26	29	.34	−.15	Charleston Ranger Station.	2.57	5 stations	.00
New England	70.9	+3.8	2 stations	95	[1] 5	First Conn. Lake, N. H.	37	2	3.98	+.12	Fort Kent, Maine	9.97	Eastport, Maine	.99
New Jersey	75.3	+3.5	Elizabeth	98	9	3 stations	50	[1] 5	7.03	+2.28	Tuckerton	19.38	Phillipsburg	2.93
New Mexico	70.5	−.2	Animas	101	22	2 stations	30	12	1.76	−.66	Valley View	5.14	Pankey Ranch	.00
New York	71.6	+4.0	Angelica	98	18	Lake Placid Club	40	28	2.86	−.93	Riverhead	7.70	Dansville	.39
North Carolina	75.9	.0	2 stations	99	[1] 10	Banners Elk	43	31	6.98	+1.47	Weldon	13.45	Hot Springs	1.94
North Dakota	68.6	+2.1	New England	105	26	2 stations	32	[1] 9	2.10	+.10	Berthold Agency	4.57	Crosby	.88
Ohio	72.7	+1.0	Gallipolis (near)	100	12	do	44	[1] 23	2.02	−1.37	Athens	5.50	Ohio State University.	.24
Oklahoma	82.2	+.7	Alva	112	30	do	48	21	2.66	−.24	Carter Tower	6.82	Hooker	.14
Oregon	66.8	+1.5	Echo	109	3	Austin	15	29	.35	−.06	Newport	2.08	14 stations	.00
Pennsylvania	73.3	+3.0	Marcus Hook	98	8	Somerset	41	5	2.98	−1.23	Colebrook	9.65	Clearfield	.41
South Carolina	78.4	−.4	2 stations	101	[1] 9	Longcreek (near)	53	31	7.37	+1.67	Caesars Head	15.47	Little Mountain	3.00
South Dakota	71.9	+1.0	Camp Crook	108	3	Castlewood	34	21	1.92	−.16	Custer	4.76	Dupree	.05
Tennessee	76.5	−.2	4 stations	98	[1] 9	Waynesboro	42	22	3.19	−.81	Morgan Springs	7.73	Milan	.77
Texas	82.3	−.5	do	110	[1] 16	2 stations	50	[1] 9	2.21	−.10	Livingston	8.32	Sinton	.17
Utah	71.0	+1.2	Springdale	112	16	Silver Lake	30	8	.66	−.38	Gooseberry Ranger Station.	2.41	2 stations	.00
Virginia	75.0	+.9	Diamond Springs	100	9	Mountain Lake	44	30	5.51	+1.13	Emporia	13.81	Monterey	1.79
Washington	67.6	+2.0	3 stations	107	[1] 3	Signal Peak	28	29	.43	−.42	Paradise Inn	2.73	13 stations	.00
West Virginia	72.7	+.9	Williamson	99	11	Bayard	38	5	2.19	−1.86	Pickens	6.33	Buckhannon No. 2	.11
Wisconsin	68.6	+1.0	Stevens Point	98	1	Laona	33	22	3.53	+.27	Pine River	7.90	Portage	1.32
Wyoming	63.4	−.5	Yoder	102	15	Snake River	18	10	.78	−.30	Newcastle	3.55	Eden	.00
Alaska (July)	55.8	+.3	No Grub	91	20	Susitna	25	28	3.26	+.68	Little Port Walter	19.14	Pilgrim Springs	.28
Hawaii	74.6	−.3	Mana (Kauai)	94	5	Kanalohuluhulu	42	15	4.85	−1.40	Kukui	38.00	10 stations	.00
Puerto Rico	78.9	.0	Utuado	99	27	Guineo Reservoir	59	[1] 8	7.14	−.27	La Mina (El Yunque)	16.01	Ensenada	1.13

[1] Other dates also.

TABLE 2.—*Climatological data for Weather Bureau Stations, August 1939*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*°F.*		*°F.*	*°F.*		*°F.*	*° F.*	*° F.*	*° F.*	*%*	*In.*	*In.*		*Miles*								*0-10*	*In.*	*In.*
New England							71.5	+4.1										83	3.76	+0.2										5.3		
Eastport	75	67	85	29.92	30.00	+0.04	63.6	+2.9	81	11	72	49	3	55	25	60	58	86	0.99	−2.0	6	7.0	s.	23	e.	30	11	10	10	5.3	0.0	0.0
Greenville, Me	1,069	4	41	28.86	30.01	.....	65.4	.....	84	12	72	43	2	59	39	62	60	...	2.19	.....	11	...	s.	...	.....	...	12	11	8	.....	.0	.0
Portland, Me	103	82	117	29.88	30.00	+.02	69.7	+3.3	84	10	76	58	31	63	20	64	62	83	2.87	−.3	13	7.0	s.	23	s.	3	19	5	7	4.2	.0	.0
Concord	288	54	72	29.69	30.00	+.02	72.0	+5.2	90	16	83	53	6	61	34	...	...	...	5.04	+1.5	8	4.6	se.	15	sw.	13	11	11	9	5.4	.0	.0
Burlington	403	11	48	29.53	29.96	−.01	70.8	+2.9	89	3	81	52	28	60	30	64	61	76	2.78	−.6	7	6.7	s.	26	s.	13	11	13	7	4.9	.0	.0
Northfield	876	12	60	29.06	29.99	+.01	67.6	+4.2	88	3	81	44	30	54	37	62	60	83	2.69	−.8	9	6.0	sw.	21	se.	8	8	15	8	5.5	.0	.0
Boston [1]	29	33	62	.....	29.98	−.01	73.8	+3.9	92	22	82	60	31	66	24	66	...	76	2.14	−1.5	9	10.0	s.	32	ne.	30	6	14	11	.....	.0	.0
Nantucket	12	14	90	29.98	29.99	.00	70.6	+2.8	84	10	78	60	2	64	21	67	66	91	4.41	+1.0	8	12.2	s.	36	ne.	31	12	7	12	5.3	.0	.0
Block Island	26	11	46	29.95	29.98	−.01	72.8	+4.3	85	22	78	61	31	67	17	69	67	87	5.22	+1.6	9	12.5	s.	38	ne.	31	16	5	10	4.3	.0	.0
Providence	159	215	251	29.93	30.00	+.01	75.0	+4.0	92	22	83	60	30	67	26	68	66	82	4.08	+.6	9	10.1	s.	33	se.	20	9	10	12	5.7	.0	.0
Hartford	159	66	100	29.91	29.96	−.03	75.2	+6.3	91	1	84	59	29	66	27	67	65	81	3.68	−.6	10	7.7	s.	25	w.	4	9	7	15	6.3	.0	.0
New Haven	106	74	153	29.96	29.98	−.01	75.2	+4.9	92	1	83	60	29	68	22	69	67	82	7.46	+3.2	9	8.7	s.	27	e.	20	9	11	11	5.9	.0	.0
Middle Atlantic States							76.4	+3.1										84	5.21	+0.9										5.9		
Albany [1]	292	26	40	29.65	29.96	−.02	73.8	+3.0	93	18	86	52	5	62	35	66	62	73	1.96	−1.8	8	6.7	s.	33	w.	13	11	10	10	5.4	.0	.0
Binghamton	871	57	79	29.07	29.98	−.01	73.8	+5.8	93	16	87	53	5	61	34	63	59	68	1.01	−2.6	8	5.7	ne.	21	w.	3	6	14	11	5.7	.0	.0
New York	314	415	454	29.63	29.95	−.05	76.8	+3.7	91	21	84	60	30	70	20	68	65	73	4.37	.0	12	11.1	s.	41	s.	3	6	14	11	6.2	.0	.0
Harrisburg [1]	351	30	49	29.60	29.97	−.04	77.2	+4.6	95	13	88	58	23	66	32	68	64	71	4.09	.0	10	6.8	w.	34	e.	19	10	6	15	6.0	.0	.0
Philadelphia	114	174	367	29.85	29.97	−.03	77.8	+3.0	93	13	85	58	30	70	20	70	67	74	6.90	+2.3	13	10.6	s.	39	s.	3	9	9	13	5.8	.0	.0
Reading	323	283	306	29.63	29.97	.....	75.7	+3.3	91	13	84	62	6	67	25	67	64	71	3.38	−.8	10	9.1	se.	35	e.	19	10	8	13	5.7	.0	.0
Scranton	805	72	104	29.13	29.97	−.03	74.0	+4.2	91	13	85	56	5	63	30	65	60	68	3.87	+.2	10	5.3	sw.	20	sw.	9	10	14	7	4.8	.0	.0
Atlantic City	52	37	172	29.90	29.95	−.05	76.4	+3.9	92	1	81	59	30	71	20	72	70	82	8.95	+4.5	9	14.6	s.	52	se.	19	12	3	16	6.1	.0	.0
Sandy Hook	22	10	57	29.94	29.96	.....	76.6	+4.1	91	9	82	61	30	71	18	70	68	79	7.31	+2.3	12	12.3	s.	42	ne.	29	7	10	14	6.4	.0	.0
Trenton	190	89	107	29.76	29.96	.....	76.2	+3.2	93	9	84	58	30	68	27	69	66	76	7.55	+2.8	12	7.6	s.	28	s.	18	6	7	18	7.1	.0	.0
Baltimore [2]	123	100	215	29.95	29.97	−.04	80.0	+4.5	97	9	88	67	31	72	21	71	68	75	3.52	−.8	10	9.5	s.	45	ne.	19	13	5	13	5.5	.0	.0
Washington	112	62	85	29.85	29.96	−.05	78.8	+3.8	96	9	88	64	29	70	25	70	...	72	3.22	−.8	7	5.8	sw.	16	n.	28	10	11	10	5.5	.0	.0
Cape Henry	18	8	84	29.94	29.96	.....	78.5	+1.6	95	21	85	65	30	72	20	73	71	84	6.63	+1.8	11	10.4	sw.	47	nw.	29	8	13	10	5.8	.0	.0
Lynchburg	686	144	184	29.27	30.00	−.02	76.4	+.8	93	2	86	61	31	67	28	68	66	79	7.66	+3.9	10	5.6	sw.	27	e.	18	9	11	11	5.9	.0	.0
Norfolk	91	80	125	29.88	29.97	−.03	79.2	+1.8	94	9	86	63	29	72	23	72	70	80	9.20	+4.0	15	8.3	sw.	33	nw.	29	5	12	14	6.9	.0	.0
Richmond [2]	144	11	52	29.80	29.97	−.04	77.8	+1.3	95	9	86	63	30	69	24	71	70	87	5.84	+1.4	12	6.6	sw.	21	se.	18	13	7	11	5.3	.0	.0
Wytheville	2,304	49	55	.....	30.02	+.01	70.4	−.1	86	9	80	54	31	60	...	...	...	82	3.11	−1.1	12	4.6	w.	16	w.	20	6	14	11	.....	.0	.0
South Atlantic States							78.8	+0.7											6.69	+1.0										5.9		
Asheville	2,253	89	104	27.73	30.02	.00	73.0	+2.5	91	10	84	53	31	62	31	65	63	83	5.14	+1.0	15	5.7	nw.	20	e.	5	4	15	12	6.4	.0	.0
Charlotte [2]	779	63	86	29.18	29.98	−.04	78.6	+1.5	94	10	88	60	29	69	24	70	69	85	5.85	+.8	12	6.2	s.	27	sw.	31	7	14	10	6.0	.0	.0
Greensboro [1]	886	6	58	29.08	30.01	.....	76.2	.....	91	9	86	59	29	67	25	70	68	86	12.53	.....	12	6.3	sw.	28	se.	6	6	11	14	6.4	.0	.0
Hatteras	11	5	50	29.97	29.98	−.02	79.6	+1.6	88	21	85	67	29	75	16	75	74	85	6.52	+.8	8	9.7	sw.	34	w.	29	8	14	9	5.6	.0	.0
Raleigh [2]	376	103	146	29.61	29.98	−.03	77.9	+.9	93	9	86	60	28	69	23	72	71	87	9.99	+4.6	12	6.9	sw.	30	sw.	3	4	16	11	6.2	.0	.0
Wilmington	72	73	107	29.92	29.99	−.01	78.8	+1.2	92	10	86	63	29	72	21	74	72	87	7.21	+.8	18	7.6	sw.	31	sw.	18	7	15	9	5.9	.0	.0
Charleston [2]	48	11	92	29.94	29.99	−.02	80.2	−.8	93	1	87	64	29	73	22	73	72	91	8.78	+2.2	16	8.9	s.	27	ne.	5	9	13	9	5.6	.0	.0
Columbia, S. C	347	70	91	29.63	30.00	−.01	79.6	.0	97	9	89	62	29	70	26	71	69	80	6.16	+.7	15	6.8	s.	31	sw.	3	13	8	10	5.2	.0	.0
Greenville, S. C	1,040	70	78	28.91	29.98	.....	77.0	+1.2	97	10	87	61	31	67	30	69	67	79	7.16	+1.7	12	5.5	sw.	23	w.	1	7	15	9	5.5	.0	.0
Augusta [2]	182	62	77	29.54	29.98	−.03	80.2	−.2	97	10	89	63	31	71	24	71	70	83	5.42	+.4	16	5.1	s.	20	nw.	29	9	13	9	5.5	.0	.0
Savannah [2]	65	73	152	29.94	29.99	−.02	81.2	+.5	97	10	90	66	31	73	24	74	73	87	5.37	−1.9	15	9.0	sw.	34	w.	18	6	16	9	6.2	.0	.0
Jacksonville	43	86	110	29.96	30.00	−.01	80.8	−.9	94	22	90	68	31	72	23	73	72	84	5.97	+.2	14	6.8	s.	26	sw.	1	3	21	7	6.2	.0	.0
Florida Peninsula							81.9	−0.2										80	8.28	+2.0										6.4		
Key West [2]	21	10	64	29.97	29.98	.00	83.2	−.3	92	3	89	60	8	77	20	77	75	78	3.73	−.8	16	7.8	e.	24	nw.	31	6	13	12	6.3	.0	.0
Miami	25	124	168	29.97	30.00	−.02	81.8	+.4	90	28	87	69	6	76	19	76	74	79	6.81	+.6	19	7.5	se.	29	s.	12	5	11	15	7.0	.0	.0
Tampa [2]	35	88	197	29.98	30.00	.00	80.7	−.8	94	20	88	70	15	73	21	75	73	84	14.29	+6.1	19	8.7	s.	45	s.	12	5	14	12	6.0	.0	.0
East Gulf States							79.8	−0.1										83	8.38	+3.1										5.9		
Atlanta [1]	976	5	70	28.97	29.97	−.04	77.8	+.8	99	9	87	62	31	69	27	70	68	80	5.91	+1.5	10	7.9	se.	31	se.	11	8	12	11	6.1	.0	.0
Macon [2]	370	79	87	29.48	29.97	−.04	78.8	−1.1	94	10	87	63	31	70	23	72	71	88	9.29	+5.0	17	6.2	s.	24	s.	16	1	15	15	7.3	.....	.....
Thomasville	273	49	58	.....	.....	.....	...	.....	...	...	...	...	...	...	...	...	...	...	...	.....	...	...	...	...	...	...	...	...	...	...	.....	.....
Apalachicola	35	11	...	29.93	29.97	.....	80.4	−.8	92	10	86	68	31	74	18	75	73	81	9.12	+1.6	13	8.0	sw.	52	ne.	12	6	10	15	6.8	.0	.0
Pensacola	56	149	185	29.91	29.97	−.01	79.2	−1.7	92	11	85	68	24	74	19	74	72	83	19.02	+11.0	15	11.5	sw.	40	sw.	16	11	13	7	5.2	.0	.0
Anniston	741	9	...	...	77.2	+.8	93	10	86	58	31	68	27	...	...	...	...	...	5.88	+1.8	11	...	s.	...	.....	...	12	12	7	.....	.0	.0
Birmingham [2]	700	11	48	29.31	29.97	−.02	78.4	−.8	93	11	87	65	25	70	24	71	69	85	8.50	+4.2	13	5.7	s.	21	s.	3	11	8	12	5.6	.0	.0
Mobile	57	86	161	29.90	29.96	−.02	80.8	−.2	94	11	89	69	28	73	23	74	72	84	8.81	+1.9	16	8.1	sw.	36	ne.	11	8	15	8	5.5	.0	.0
Montgomery [2]	218	92	105	29.71	29.96	−.03	79.6	−1.2	95	10	88	64	31	72	24	72	71	87	15.58	+11.4	18	6.7	sw.	26	se.	13	9	11	11	5.5	.0	.0
Meridian [2]	375	67	92	29.63	29.95	−.03	80.6	+1.1	96	9	90	66	30	71	27	72	71	85	2.23	−2.3	6	5.1	sw.	22	ne.	11	10	15	6	5.1	.0	.0
Vicksburg	247	82	102	29.70	29.95	−.03	81.8	+1.0	94	17	91	68	29	73	22	73	71	77	2.16	−1.3	10	6.6	sw.	30	sw.	17	9	15	7	5.5	.0	.0
New Orleans [1]	53	76	84	29.93	29.96	−.02	82.7	+.5	96	11	91	71	4	75	23	75	74	82	5.68	−.3	16	5.8	sw.	21	ne.	11	3	15	13	6.4	.0	.0
West Gulf States							83.2	+1.2										72	2.24	−0.8										4.6		
Shreveport [2]	249	92	227	29.75	29.94	−.03	85.3	+3.3	102	12	97	66	17	74	34	74	71	72	2.66	.0	5	8.7	s.	36	sw.	2	14	14	3	4.3	.0	.0
Bentonville	1,303	12	51	28.58	29.91	−.06	77.7	+1.2	99	30	90	54	21	66	28	...	...	...	3.30	−.7	8	5.5	s.	18	sw.	24	12	14	5	.....	.0	.0
Fort Smith	463	57	82	29.48	29.94	−.03	83.6	+3.1	102	31	98	66	19	72	34	70	64	59	1.21	−2.1	4	6.3	e.	31	nw.	24	13	14	4	4.4	.0	.0
Little Rock [2]	357	94	102	.....	29.94	−.04	80.8	+1.0	97	12	90	65	27	71	24	72	70	77	2.92	−.8	10	6.8	sw.	38	nw.	27	14	14	3	4.0	.0	.0
Austin [2]	605	68	90	29.30	29.93	.....	84.0	+.2	101	19	95	68	29	73	29	72	69	72	1.62	−.4	6	6.2	s.	29	se.	16	14	11	6	4.2	.0	.0
Brownsville [2]	57	88	96	29.90	29.92	.....	83.1	−.8	94	19	91	72	28	76	19	75	73	81	1.92	−.6	9	9.3	se.	25	s.	7	4	22	8	5.5	.0	.0
Corpus Christi [2]	20	11	78	29.89	29.94	+.01	83.8	+1.3	94	17	90	74	2	78	17	75	74	83	1.38	−.9	2	10.7	s.	27	se.	8	13	14	4	4.2	.0	.0
Dallas [2]	512	220	227	29.40	29.91	.....	85.0	.....	104	31	95	65	23	75	23	72	66	60	1.16	−1.6	5	9.7	s.	44	n.	23	14	13	4	4.3	.0	.0
Fort Worth [2]	679	92	110	29.20	29.92	−.02	85.4	+2.4	105	31	97	69	14	74	32	71	64	58	1.44	−1.2	4	8.4	s.	33	sw.	14	17	12	2	3.0	.0	.0
Galveston [2]	54	106	114	29.95	29.96	.00	83.5	+.5	93	29	88	72	2	79	16	76	74	79	1.99	−2.3	5	8.9	s.	22	s.	7	12	15	4	4.3	.0	.0
Houston [2]	138	157	190	29.80	29.95	.....	83.8	+.6	98	13	92	71	27	75	24	74	72	80	1.52	−3.6	4	8.0	s.	25	s.	23	7	19	5	5.4	.0	.0
Palestine	510	64	72	29.43	29.95	−.02	83.8	+2.0	102	31	94	68	23	73	27	72	68	67	2.69	+.5	8	6.5	s.	27	s.	19	11	15	5	5.1	.0	.0
Port Arthur	34	59	106	29.92	29.96	.....	83.8	.....	96	13	92	72	21	76	22	75	73	79	2.44	−.8	12	10.1	s.	29	s.	2	5	18	8	5.6	.0	.0
San Antonio	693	111	301	29.34	29.93	.00	83.4	−.1	99	19	94	67	29	73	27	73	69	71	5.08	+2.7	9	9.3	se.	38	e.	13	8	14	9	5.3	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau stations, August 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*		*°F.*	*°F.*		*°F.*	*°F.*	*°F.*	*°F.*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							75.7	+0.7										75	2.07	−1.4										4.7		
Chattanooga [2]	762	71	214	29.26	29.98	−0.02	78.8	+1.3	96	9	89	61	31	68	30	69	67	82	2.62	−1.4	14	6.9	w.	23	nw.	9	11	10	10	5.4	0.0	0.0
Knoxville [2]	995	66	84	28.97	29.98	−.03	77.6	+1.4	97	11	88	58	23	68	32	68	65	77	2.12	−1.8	12	4.6	e.	18	nw.	9	15	8	8	4.6	.0	.0
Memphis [2]	399	78	86	29.64	29.93	−.05	80.2	+.8	95	13	88	64	23	72	23	72	69	77	2.23	−1.1	5	6.5	sw.	28	ne.	23	7	17	7	5.3	.0	.0
Nashville [2]	546	168	188	29.33	29.96	−.04	77.8	.0	91	11	88	56	22	68	29	69	66	75	1.87	−1.8	10	6.6	w.	33	se.	15	8	13	10	5.5	.0	.0
Lexington	989	6	----	29.06	30.00	−.01	75.0	+.5	95	12	87	52	22	63	33	----	----	----	1.80	−1.6	6	----	n.	----	----	----	22	4	5	.0	.0	.0
Louisville [2]	525	106	120	29.39	29.97	−.03	76.4	−.6	91	13	85	60	22	67	24	68	65	77	2.98	−.4	12	6.5	ne.	27	sw.	8	16	13	2	3.4	.0	.0
Evansville	431	76	116	29.50	29.96	−.03	77.7	+.3	94	15	87	62	22	68	25	68	64	68	3.65	+.3	11	6.4	s.	33	n.	12	14	9	8	4.6	.0	.0
Indianapolis [2]	823	98	129	29.12	29.97	−.03	74.6	+.9	90	16	84	57	27	65	26	65	62	76	2.91	−.4	7	6.5	ne.	22	sw.	8	12	14	5	4.3	.0	.0
Terre Haute	575	63	149	29.35	29.96	----	76.2	----	92	12	86	62	22	68	30	66	62	68	3.57	+.3	8	7.3	sw.	30	sw.	8	16	9	6	4.2	.0	.0
Cincinnati [2]	627	11	51	29.32	29.99	−.02	74.6	+1.0	92	12	85	58	27	64	29	66	63	75	2.16	−1.2	5	5.3	ne.	23	nw.	3	16	8	7	4.2	.0	.0
Columbus [2]	822	90	110	29.10	29.97	−.04	74.9	+1.9	93	13	85	56	27	64	28	65	61	72	.49	−2.8	4	7.7	s.	41	s.	12	12	16	3	4.1	.0	.0
Dayton	900	186	213	29.04	29.97	----	73.6	+.2	90	15	84	56	7	64	28	65	61	69	1.47	−1.8	7	7.5	n.	27	sw.	8	16	11	4	3.8	.0	.0
Elkins [2]	1,947	65	83	27.96	30.03	+.01	70.1	+1.0	89	11	82	51	23	58	37	63	62	88	.83	−3.0	11	4.3	se.	24	w.	9	4	15	12	6.5	.0	.0
Parkersburg	637	77	84	29.31	29.98	−.03	74.7	+.8	92	13	85	56	23	64	31	67	64	75	1.13	−2.4	7	4.7	se.	14	sw.	21	13	14	4	4.2	.0	.0
Pittsburgh [1]	1,273	39	54	28.66	29.99	−.02	73.5	+.6	90	12	84	57	26	63	30	65	61	70	1.25	−2.0	8	8.2	sw.	25	w.	7	8	12	11	5.7	.0	.0
Lower Lake Region							72.8	+3.2										73	1.72	−1.3										4.2		
Buffalo [2]	768	243	280	29.22	29.98	−.01	72.0	+3.4	88	19	79	59	29	65	23	64	60	73	3.79	+.7	9	12.1	sw.	47	w.	12	15	13	3	3.8	.0	.0
Canton	448	10	61	29.48	29.95	----	70.0	+3.4	90	12	82	49	2	58	34	64	60	71	1.74	−1.9	11	6.4	w.	29	w.	9	11	16	4	4.4	.0	.0
Ithaca	836	77	100	29.09	29.97	----	73.6	+5.0	94	18	86	53	28	61	37	64	60	70	1.46	−1.9	6	6.6	nw.	26	se.	19	7	21	3	5.0	.0	.0
Oswego	335	71	85	29.60	29.96	−.03	72.1	+3.7	94	12	80	58	28	64	27	66	63	74	1.36	−1.2	7	6.8	s.	22	nw.	30	9	16	6	4.6	.0	.0
Rochester [2]	523	86	102	29.38	29.98	−.01	73.4	+4.2	95	12	82	58	27	65	29	64	62	76	1.65	−1.2	7	7.0	sw.	29	sw.	9	13	15	3	4.4	.0	.0
Syracuse [2]	596	65	79	29.53	29.96	−.03	74.2	+5.4	93	12	84	57	30	64	26	66	62	74	1.40	−1.5	8	5.7	s.	19	nw.	3	11	14	6	4.8	.0	.0
Erie	714	57	81	29.22	29.96	−.05	72.7	+3.1	91	12	80	60	11	65	25	66	63	73	2.10	−1.2	11	6.7	s.	20	sw.	9	15	12	4	3.7	.0	.0
Cleveland [2]	762	267	318	29.12	29.98	−.03	73.2	+3.2	90	12	80	59	22	66	26	65	61	72	.72	−2.0	6	11.8	s.	32	sw.	9	16	10	5	3.4	.0	.0
Sandusky	629	5	67	29.28	29.96	−.05	74.0	+2.2	91	12	83	58	24	65	28	----	----	----	2.28	−.9	5	7.4	sw.	24	sw.	12	15	9	7	4.4	.0	.0
Toledo [2]	628	79	87	29.30	29.98	−.02	72.4	+1.1	88	1	82	57	26	63	26	64	61	75	1.08	−1.8	6	8.4	w.	28	w.	21	18	10	3	3.3	.0	.0
Fort Wayne	857	69	84	29.10	29.97	----	72.8	+1.1	89	15	83	56	22	63	28	64	60	73	1.61	−1.5	6	7.5	ne.	26	s.	8	14	12	5	4.5	.0	.0
Detroit [1]	626	5	78	29.30	29.96	−.05	73.0	+2.7	92	1	83	56	25	63	27	64	60	70	1.39	−1.4	8	8.6	s.	27	sw.	21	11	12	8	4.6	.0	.0
Upper Lake Region							68.8	+2.4										78	3.71	+0.8										5.0		
Alpena	609	13	89	29.30	29.97	−.03	68.4	+4.3	92	6	78	51	25	59	34	62	60	78	4.08	+1.2	13	9.1	nw.	28	nw.	29	13	12	6	4.7	.0	.0
Escanaba	612	41	49	29.30	29.95	−.04	66.6	+2.3	86	5	75	49	22	58	25	61	59	82	2.62	−.6	14	9.8	s.	28	nw.	9	10	8	13	5.9	.0	.0
Grand Rapids [2]	707	70	244	29.22	29.95	−.05	72.4	+2.7	91	2	82	56	22	63	27	63	60	75	6.22	+3.6	9	9.2	sw.	34	sw.	2	13	11	7	4.6	.0	.0
Lansing	878	5	90	29.04	29.96	----	70.0	+1.5	90	1	80	53	26	60	30	63	60	77	1.97	−.8	9	7.0	sw.	22	sw.	2	15	13	3	4.2	.0	.0
Marquette	734	44	69	29.15	29.94	−.04	65.8	+2.0	86	17	73	52	22	58	27	60	57	77	3.28	+.6	11	6.5	nw.	26	sw.	28	6	12	13	6.1	.0	.0
Sault Saint Marie [1]	724	5	33	29.16	29.94	−.05	64.6	+2.5	84	14	75	48	25	54	34	60	58	84	4.48	+1.9	16	6.1	nw.	21	nw.	20	8	9	14	6.1	.0	.0
Chicago	673	7	131	29.26	29.97	−.03	72.6	+1.0	90	15	80	56	22	65	25	65	62	75	1.47	−1.7	11	8.5	sw.	26	sw.	8	15	9	7	4.0	.0	.0
Green Bay	617	109	141	29.29	29.95	−.04	70.0	+2.3	91	5	79	52	22	61	30	62	59	72	2.27	−.9	8	8.9	sw.	32	ne.	21	10	7	14	5.6	0	0
Milwaukee [2]	681	97	221	29.22	29.97	−.03	72.0	+2.8	90	5	80	55	22	64	24	63	60	77	5.03	+2.4	8	9.8	w.	33	w.	8	13	10	8	4.7	0	0
Duluth	1,133	5	47	28.73	29.92	−.05	65.6	+3.0	91	5	74	50	23	57	29	59	57	79	5.66	+2.5	12	10.5	ne.	29	nw.	8	11	13	7	4.5	.0	.0
North Dakota							69.7	+3.7										58	2.06	−0.2										4.2		
Moorhead, Minn	940	50	58	28.94	29.89	−.07	70.5	+4.4	94	5	83	44	21	58	37	60	53	62	1.49	−1.4	12	8.1	s.	27	sw.	26	10	14	7	4.5	.0	.0
Bismarck [2]	1,677	8	57	28.18	29.92	−.02	69.9	+2.6	99	26	84	43	9	55	44	56	47	56	1.81	.0	9	7.5	nw.	27	nw.	21	15	9	7	4.3	.0	.0
Devils Lake	1,478	11	44	28.35	29.90	−.04	69.0	+4.2	98	6	83	44	9	55	40	57	50	60	2.76	+.3	8	8.2	nw.	27	nw.	2	12	8	11	5.1	.0	.0
Lemmon, S. Dak	2,602	4	38	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Grand Forks	832	11	71	----	----	----	70.3	+4.9	96	5	84	44	9	56	42	60	54	----	1.95	−.7	10	8.1	se.	----	----	----	----	----	----	----	.0	.0
Williston	1,878	42	50	27.97	29.91	−.02	68.6	+2.5	98	26	82	43	23	55	42	55	46	54	2.31	+.8	11	7.2	se.	36	w.	15	21	7	3	2.7	.0	.0
Upper Mississippi Valley							73.0	+0.2										74	4.70	+1.4										5.0		
Minneapolis-St. Paul, Minn. [1]	838	32	61	29.04	29.93	−.04	71.2	+1.3	94	5	82	52	24	60	33	63	58	71	3.65	+.5	12	8.1	s.	45	se.	10	12	10	9	4.9	.0	.0
Springfield, Minn	1,025	4	42	----	----	----	70.8	----	94	5	83	46	21	59	37	62	58	...	4.92	----	11	5.1	s.	----	----	----	----	----	----	----	.0	.0
La Crosse [2]	714	11	48	29.23	29.94	−.04	71.2	+1.2	91	5	82	53	24	61	33	64	61	75	6.74	+3.0	9	4.2	s.	19	se.	10	12	11	8	5.1	.0	.0
Madison	974	70	78	28.93	29.95	−.04	71.3	+1.5	91	1	80	54	9	62	24	63	59	71	2.61	−.6	9	6.2	s.	29	se.	11	9	7	15	6.2	.0	.0
Charles City	1,015	10	51	28.90	29.97	.00	69.3	+.2	90	1	80	48	9	58	33	62	59	75	3.75	+.3	8	5.0	se.	19	sw.	1	10	10	11	5.6	.0	.0
Davenport	606	66	161	29.32	29.97	−.01	73.2	+.1	92	1	83	56	23	63	28	65	61	73	5.60	+2.1	11	7.7	w.	38	se.	16	12	10	9	5.2	.0	.0
Des Moines [2]	860	5	99	28.94	29.95	−.02	71.7	−1.4	89	1	82	53	9	62	30	63	60	73	5.58	+2.1	11	7.6	se.	30	nw.	10	13	9	9	5.0	.0	.0
Dubuque	699	60	79	29.22	29.96	−.02	71.9	+.2	92	1	82	54	23	62	28	64	61	74	4.27	+1.0	10	4.6	s.	18	se.	11	12	5	14	5.6	.0	.0
Keokuk	614	64	78	29.31	29.96	−.02	74.0	−1.0	93	7	84	56	21	64	29	66	62	71	4.81	+1.6	12	5.8	e.	25	nw.	20	12	11	8	5.3	.0	.0
Cairo	358	87	93	29.58	29.95	−.04	77.8	.0	93	13	87	61	22	69	25	70	67	75	1.22	−1.8	8	5.9	s.	23	n.	22	14	7	10	4.7	.0	.0
Peoria [2]	609	11	45	29.27	29.97	−.02	73.2	+.7	92	1	85	54	22	62	31	65	62	79	2.38	−.7	9	4.1	ne.	16	w.	22	18	9	4	3.6	.0	.0
Springfield, Ill. [2]	636	5	191	29.31	29.96	−.03	75.3	+.8	95	1	86	57	21	65	29	66	63	79	5.75	+2.6	10	9.1	s.	42	n.	6	11	11	9	4.9	.0	.0
St. Louis [2]	568	179	303	29.37	29.96	−.03	76.4	−1.1	93	7	85	60	21	68	25	67	63	68	10.06	+7.1	10	9.3	ne.	32	sw.	20	19	7	5	3.3	.0	.0
Missouri Valley							74.9	+0.7										67	3.26	−0.2										4.7		
Columbia, Mo. [2]	784	6	66	29.13	29.94	−.03	75.4	−.2	97	7	87	53	21	64	30	66	63	76	8.71	+5.1	11	6.7	e.	26	n.	22	10	15	6	5.1	.0	.0
Kansas City [1]	750	32	45	29.14	29.92	−.05	77.0	+.4	100	30	88	55	23	66	33	67	62	67	4.64	+.6	11	7.4	e.	33	w.	7	11	13	7	5.0	.0	.0
St. Joseph [2]	967	11	49	29.06	29.93	----	76.2	−.3	97	30	87	55	23	65	32	66	63	74	2.40	−1.4	10	7.7	e.	27	nw.	7	12	15	4	4.7	.0	.0
Springfield, Mo.	1,324	5	78	28.85	29.96	−.01	76.2	+.5	95	6	87	52	21	66	31	67	65	78	3.60	−.5	10	6.9	e.	24	w.	20	10	14	7	5.0	.0	.0
Topeka	987	65	87	28.90	29.92	----	77.8	+1.6	107	30	89	54	21	66	35	67	61	70	3.51	−.6	10	8.3	e.	27	se.	12	10	14	7	5.1	.0	.0
Lincoln [2]	1,109	11	81	28.68	29.91	−.04	75.0	+.6	99	30	87	52	21	63	35	63	57	61	2.61	−1.0	12	8.6	e.	27	s.	15	12	11	8	4.6	.0	.0
Omaha [1]	982	31	44	28.91	29.94	−.02	74.6	+.2	96	3	86	51	21	63	36	64	59	65	2.03	−1.0	12	8.8	se.	31	nw.	20	14	7	10	5.0	.0	.0
Valentine	2,598	47	54	27.28	29.94	.00	71.4	−.3	99	13	86	43	23	57	41	59	50	56	2.19	.0	7	8.4	w.	30	nw.	9	15	12	4	3.5	.0	.0
Sioux City	1,138	64	106	28.74	29.93	−.02	72.6	+.6	95	14	84	47	21	61	39	63	57	63	1.97	−1.2	11	7.9	se.	31	nw.	8	12	9	10	4.9	.0	.0
Huron	1,289	27	41	28.57	29.92	−.03	73.2	+3.8	98	4	88	44	21	59	46	60	51	56	.99	−1.5	6	12.5	se.	34	nw.	19	15	13	3	3.8	.0	.0
Northern Slope							68.4	+2.3										47	0.73	−0.5										4.0		
Billings	3,140	5	----	26.35	29.97	----	69.4	----	96	28	84	40	10	54	42	54	41	42	.76	----	4	9.7	sw.	42	n.	6	13	12	6	4.2	.0	.0
Havre	2,507	11	67	27.36	29.95	+.04	68.8	+3.4	98	28	86	39	10	52	47	53	40	44	.58	−.6	5	7.4	sw.	30	s.	25	19	9	3	3.1	.0	.0
Helena	4,124	85	111	25.86	29.97	+.03	67.8	+2.8	93	3	82	39	10	54	42	51	37	38	.48	−.3	5	8.0	sw.	27	sw.	26	17	8	6	3.8	.0	.0
Missoula	3,263	80	91	----	----	----	70.2	+4.6	99	3	88	44	8	53	47	53	40	43	.10	−.8	3	7.0	e.	37	e.	19	19	9	3	3.1	.0	.0
Kalispell	2,973	48	56	26.95	29.94	+.01	66.0	+3.2	92	4	82	38	7	50	41	51	39	42	.21	−.7	6	6.7	nw.	23	w.	25	15	11	5	3.7	.0	.0
Miles City [2]	2,371	48	55	27.23	29.92	−.01	71.8	+.3	98	4	86	44	8	57	42	55	43	43	.50	−.6	7	5.8	s.	28	nw.	6	15	11	5	4.1	.0	.0
Rapid City [2]	3,259	50	58	26.69	29.94	+.01	71.6	+2.1	98	13	85	44	10	58	39	55	44	46	1.28	−.4	9	7.9	w.	32	sw.	18	16	11	4	3.8	.0	.0
Cheyenne [1]	6,144	5	39	24.07	29.96	+.04	66.2	+.6	90	4	82	37	20	50	48	50	40	50	.43	−1.1	9	9.4	nw.	35	n.	7	11	15	5	4.9	.0	.0
Lander	5,352	60	68	24.74	29.94	+.02	67.1	+1.6	92	13	83	38	8	51	40	51	38	43	.20	−.3	4	4.7	sw.	29	se.	24	16	10	5	4.2	.0	.0
Sheridan	3,790	10	47	26.15	29.99	----	66.3	----	95	4	84	35	20	48	48	54	46	60	2.22	+1.3	6	4.5	s.	22	nw.	6	18	10	2	3.4	.0	.0
Yellowstone Park	6,235	12	46	24.02	30.07	+.14	60.8	+1.7	85	16	77	31	10	44	47	46	35	46	.91	−.3	6	7.2	sw.	33	sw.	28	11	13	7	4.5	.0	.0
North Platte [2]	2,821	11	51	27.10	29.93	−.01	73.4	+2.6	98	5	88	46	8	59	44	61	55	63	1.17	−1.2	4	6.8	se.	23	n.	7	11	12	8	4.9	.0	.0

See footnotes at end of table.

TABLE 2.—*Climatological data for Weather Bureau Stations, August 1939*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F.*		°*F.*	°*F.*		°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
Middle Slope							**77.1**	**+1.2**										**55**	**3.16**	**+0.7**										**4.2**		
Denver [1]	5,292	106	113	24.78	29.93	+0.01	71.8	+1.1	92	17	85	46	20	58	38	54	43	45	0.43	−1.0	6	7.7	s.	26	nw.	21	10	15	6	4.7	0.0	0.0
Pueblo [1]	4,690	79	86	25.23	29.91	.00	73.2	+.5	95	24	88	48	21	58	43	57	48	51	.68	−1.1	7	6.7	e.	26	ne.	16	16	12	3	4.2	.0	.0
Chadron, Nebr.	3,439	4	58																												
Concordia	1,392	50	58	28.48	29.91	−.04	76.8	+.3	100	29	89	56	21	65	33	66	60	62	4.37	+1.5	10	7.9	se.	19	se.	5	14	12	5	4.5	.0	.0
Dodge City	2,509	10	86	27.36	29.89	−.04	79.0	+1.3	102	30	92	54	8	66	34	64	56	55	2.09	−.6	8	11.2	sw.	31	se.	19	13	16	2	3.7	.0	.0
Wichita [1]	1,358	85	93	28.47	29.90	−.05	80.0	+1.7	105	30	92	57	21	68	32	67	60	60	5.84	+2.7	7	9.8	se.	38	ne.	15	13	15	3	4.0	.0	.0
Oklahoma City [1]	1,214	10	47	28.57	29.90	−.04	82.1	+2.4	101	30	94	60	21	71	32	68	62	58	5.52	+2.6	9	7.7	s.	26	ne.	22	14	12	5	4.2	.0	.0
Southern Slope							**79.9**	**+0.2**										**61**	**2.77**	**+0.5**										**4.0**		
Abilene [1]	1,738	10	56	28.14	29.90	−.02	83.2	+1.2	101	31	95	64	8	72	32	68	61	60	1.95	−.3	5	8.4	s.	27	s.	6	14	9	8	4.6	.0	.0
Amarillo [1]	3,676	10	49	26.30	29.91	−.01	77.7	+2.0	99	30	90	55	8	65	35	63	56	61	3.28	+.2	7	7.8	s.	21	ne.	7	18	13	6	3.4	.0	.0
Del Rio	960	63	71	28.92	29.88	−.02	82.2	−2.0	96	25	91	68	9	73	24	71	67	66	4.47	+2.8	11	8.1	se.	41	e.	16	11	11	9	5.0	.0	.0
Roswell	3,566	75	85	26.39	29.92	+.04	76.4	−.2	95	19	89	56	31	64	36	63	55	56	1.38	−.8	8	7.2	s.	36	se.	10	18	13	0	3.0	.0	.0
Southern Plateau							**81.2**	**+1.9**										**50**	**0.66**	**−0.5**										**3.4**		
El Paso [1]	3,778	82	101	26.05	29.85	+.01	80.7	+1.5	98	22	93	65	12	69	33	63	53	49	.91	−.8	7	7.6	e.	26	ne.	11	19	11	1	2.8	.0	.0
Albuquerque [1]	5,314	5	39	24.80	29.87	.....	75.7	+1.8	94	19	90	56	14	62	33	59	50	51	.54	−.7	5	8.3	se.	38	nw.	18	15	11	5	3.9	.0	.0
Santa Fe	7,013	38	53	23.38	29.95	+.06	67.8	+.4	87	19	80	50	8	55	33	53	45	52	.94	−1.3	10	5.4	e.	24	ne.	16	7	18	6	5.3	.0	.0
Flagstaff	6,907	10	59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Phoenix [2]	1,107	39	51	28.66	29.77	−.02	90.2	+1.7	109	21	102	70	7	78	31	71	62	44	.84	−.1	7	6.0	w.	30	e.	16	17	9	5	3.5	.0	.0
Yuma	141	9	54	29.63	29.77	+.01	92.6	+2.2	111	21	106	74	21	79	37	75	67	50	.12	−.4	1	5.6	s.	22	se.	22	25	4	2	1.6	.0	.0
Independence	3,957	5	26	25.90	29.90	+.09	79.9	+3.8	102	16	96	55	31	64	40	.....	.....	.....	.59	+.5	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.0	.0
Middle Plateau							**74.7**	**+3.3**										**36**	**0.54**	**−0.2**										**3.2**		
Reno [2]	4,527	61	76	25.60	29.92	+.08	74.3	+5.6	97	2	91	47	29	57	42	53	40	44	.48	+.3	2	6.5	w.	29	s.	22	24	6	1	1.9	.0	.0
Tonopah	6,090	12	20	.....	.....	.....	75.4	.....	93	16	87	55	24	64	31	54	38	.....	.08	.....	3	.....	se.	.....	.....	.....	.....	.....	.....	.....	.0	.0
Winnemucca	4,344	18	56	25.62	29.91	+.03	73.4	+4.1	102	3	94	40	29	52	51	51	30	25	.04	−.2	2	6.8	sw.	28	s.	24	20	9	2	2.4	.0	.0
Modena	5,473	10	46	24.67	29.88	+.02	71.8	+2.6	96	16	88	48	31	55	41	54	42	42	1.22	−.1	8	9.3	w.	30	nw.	6	7	19	5	4.9	.0	.0
Salt Lake City [1]	4,227	32	46	25.74	29.88	+.03	76.8	+2.3	98	14	91	54	8	63	35	56	41	38	.26	−.6	3	6.7	n.	29	n.	28	18	10	3	3.4	.0	.0
Grand Junction	4,602	60	68	25.40	29.90	.00	77.2	+1.8	98	16	91	55	7	63	38	57	42	35	.68	−.5	2	5.9	se.	24	w.	28	20	6	5	3.2	.0	.0
Northern Plateau							**73.0**	**+3.6**										**36**	**0.06**	**−0.4**										**2.6**		
Baker	3,471	36	54	26.56	29.97	+.02	68.4	+3.8	94	4	87	39	7	50	47	49	35	43	.04	−.4	1	6.5	n.	22	n.	6	18	11	2	3.0	.0	.0
Boise [1]	2,739	79	87	27.15	29.90	−.03	74.7	+2.9	100	3	91	46	7	59	42	56	43	44	T	−.2	0	5.2	se.	21	nw.	24	21	6	4	3.0	.0	.0
Pocatello [1]	4,478	5	31	25.51	29.92	.00	70.6	+1.0	96	14	89	40	20	53	50	51	34	32	.10	−.6	4	8.8	w.	35	n.	30	20	8	3	3.0	.0	.0
Spokane [1]	1,929	101	110	27.90	29.93	−.02	72.6	+4.5	101	3	88	48	29	58	44	53	38	36	.04	−.6	1	6.2	s.	23	s.	28	27	3	1	1.8	.0	.0
Walla Walla	991	57	65	28.88	29.92	−.03	76.4	+3.7	103	3	91	50	29	62	40	56	38	28	T	−.5	0	5.8	s.	19	s.	24	21	7	3	2.5	.0	.0
Yakima	1,076	58	67	28.82	29.95	.....	75.1	+5.6	102	3	90	42	29	60	40	57	43	36	.18	.0	1	6.5	nw.	22	sw.	28	22	5	4	2.6	.0	.0
North Pacific Coast Region							**65.9**	**+2.5**										**66**	**0.60**	**−0.2**										**3.9**		
North Head	211	8	56	29.83	30.05	+.02	58.8	+1.2	86	8	64	49	9	53	35	56	54	88	.47	−.6	8	11.4	n.	41	s.	28	9	6	16	6.2	.0	.0
Seattle [2]	125	90	321	29.99	30.03	+.03	66.6	+3.5	91	3	77	50	30	57	31	58	52	67	.59	−.1	4	7.4	n.	26	s.	28	15	5	11	4.3	.0	.0
Tacoma	263	172	201	29.83	30.03	+.01	65.2	+2.6	91	3	75	49	29	56	33	.....	.....	.....	.34	−.4	4	7.3	n.	24	sw.	25	17	6	8	3.7	.0	.0
Tatoosh Island	96	9	55	29.95	30.05	+.05	56.2	+.9	74	8	61	49	18	52	21	52	52	86	.51	−1.5	12	10.7	s.	33	ne.	19	11	7	13	5.7	.0	.0
Medford [1]	1,329	29	58	28.55	29.93	.....	74.0	+2.9	104	19	93	43	29	55	51	57	45	44	T	−.2	0	.....	nw.	.....	.....	.....	25	4	2	1.7	.0	.0
Portland, Oreg. [2]	154	68	106	29.96	30.00	−.01	70.0	+3.3	100	2	82	49	29	58	36	60	53	62	1.52	+.9	6	6.6	nw.	19	nw.	1	16	9	6	3.5	.0	.0
Roseburg	510	45	76	29.43	29.97	−.03	70.8	+2.8	104	2	87	43	29	54	47	58	48	52	.74	+.4	3	4.5	n.	17	nw.	6	26	2	3	2.0	.0	.0
Middle Pacific Coast Region							**68.8**	**+1.6**										**60**	**0.02**	**0.0**										**3.6**		
Eureka	60	72	88	29.95	30.02	+.02	56.8	+.8	67	30	61	50	30	52	17	54	52	86	.06	−.1	4	6.2	nw.	18	sw.	7	3	11	17	7.3	.0	.0
Redding [1]	722	20	34	29.10	29.86	.....	82.7	+2.2	107	17	97	56	28	68	38	59	39	23	.00	.0	0	7.4	nw.	25	nw.	27	26	3	2	1.4	.0	.0
Sacramento [2]	66	92	115	29.84	29.87	+.02	75.0	+2.1	105	17	92	51	28	58	44	59	49	51	.00	.0	0	7.9	s.	18	sw.	31	27	4	0	.9	.0	.0
San Francisco	155	112	132	29.78	29.94	+.02	60.6	+1.5	81	17	66	52	5	56	24	56	54	82	T	.0	0	10.9	w.	28	w.	27	10	15	6	4.7	.0	.0
South Pacific Coast Region							**74.7**	**+1.2**										**62**	**T**	**0.0**										**2.9**		
Fresno [1]	327	97	105	29.55	29.84	+.02	81.0	+.3	107	18	99	53	29	63	44	62	47	37	T	.0	0	7.0	nw.	19	nw.	27	28	1	2	1.4	.0	.0
Los Angeles	338	159	191	29.54	29.89	+.01	73.0	+1.9	89	17	82	60	29	64	27	64	60	70	.01	.0	1	5.2	sw.	15	w.	26	19	11	1	2.7	.0	.0
San Diego [2]	87	62	70	29.87	29.90	+.01	70.1	+1.4	81	25	75	61	30	65	19	65	62	78	T	.0	0	6.6	w.	16	s.	17	11	15	5	4.5	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.90	29.98	.....	80.5	.0	90	8	83	74	6	76	16	.....	.....	.....	3.99	−2.0	16	9.8	e.	27	e.	11	2	21	8	5.9	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	.....	[3]29.80	−.03	81.7	+.5	92	26	88	72	3	75	16	.....	.....	[3]86	5.13	−2.6	20	6.5	nw.	21	n.	17	0	8	23	8.0	.0	.0
Cristobal	36	6	97	.....	[3]29.81	−.03	82.0	+1.8	89	16	86	73	11	78	14	77	76	[3]84	11.66	−3.6	23	8.9	n.	26	nw.	11	0	4	27	8.8	.0	.0
Alaska																																
Fairbanks	454	11	87	[4]29.26	[4]29.77	.....	53.6	−1.6	76	9	65	32	23	42	32	49	44	72	1.44	−.6	12	6.4	e.	22	se.	3	0	3	28	8.6	.0	.0
Juneau	80	96	116	[4]29.93	[4]30.02	.....	53.6	−1.7	73	9	58	44	24	49	21	50	48	81	12.24	+5.0	24	7.0	s.	24	se.	3	0	2	29	9.6	.0	.0
Nome	22	5	57	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hawaiian Islands																																
Honolulu	38	86	100	29.93	29.97	−.01	77.7	−.7	84	25	82	70	6	74	13	70	70	72	.53	−.8	13	10.3	e.	22	ne.	2	2	20	9	6.1	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport, other data city-office records.
[3] Observations taken hourly.
[4] Pressure not reduced to a mean of 24 hours.

NOTE.—Except as indicated by notes, 1 and 2, data in table 2 are city office records.

TABLE 3.—*Data furnished by the Canadian Meteorological Service, August 1939*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max.+ mean min.÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99				55.6	−1.0	62.4	48.7	73	40	5.53	+1.52	
Sydney, Cape Breton Island	48	29.89	30.02	+0.04	67.3	+3.6	76.5	58.1	87	39	1.62	−2.08	
Ha'ifax, Nova Scotia	88	29.76	30.02	+.03	69.4	+4.9	78.4	62.3	86	53	2.13	−2.30	
Yarmouth, Nova Scotia	65	29.90	30.01	+.01	65.2	+4.6	74.3	56.1	82	48	1.90	−1.60	
Charlottetown, Prince Edward Island	38	29.93	30.01	+.05	69.4	+5.0	78.5	60.4	86	46	1.54	−1.63	
Chatham, New Brunswick	28	29.85	29.95	.00	68.6	+4.1	80.5	56.8	88	42	.79	−3.28	
Father Point, Quebec	20												
Quebec, Quebec	296												
Doucet, Quebec	1,236	28.58	29.91	−.08	61.4	+4.4	74.0	48.9	83	32	4.42	+.92	
Montreal, Quebec	187												
Ottawa, Ontario	236	29.58	29.95	+.01	69.6	+3.9	80.5	58.6	89	49	1.77	−1.11	
Kingston, Ontario	285	29.66	29.97	−.01	70.1	+3.5	80.3	59.9	88	53	2.68	−.07	
Toronto, Ontario	379	29.56	29.96	−.03	72.2	+5.2	81.3	63.2	87	57	4.17	+1.37	
Cochrane, Ontario	930				62.0	+2.0	71.5	52.5	83	44	4.24	+.94	
White River, Ontario	1,244	28.63	29.95	−.01	59.6	+1.9	73.5	45.6	80	36	2.22	−.73	
London, Ontario	808	29.11	29.97		69.4	+3.0	81.2	57.5	87	50	1.22	−1.62	
Southampton, Ontario	656	29.26	29.96	−.04	67.4	+2.6	76.3	58.6	85	51	3.88	+1.58	
Parry Sound, Ontario	688	29.29	29.97	−.01	69.2	+5.0	78.0	60.3	86	55	7.50	+4.74	
Port Arthur, Ontario	644	29.22	29.93	−.04	62.0	+1.6	72.6	51.4	83	40	2.13	−.66	
Winnipeg, Manitoba	760	29.05	29.90	−.06	67.8	+3.8	79.8	55.8	94	46	5.51	+3.17	
Minnedosa, Manitoba	1,690	28.14	29.92	−.01	65.1	+4.5	79.8	50.4	97	35	2.34	+.21	
Le Pas, Manitoba	860	28.91	29.86	−.05	63.4	+2.8	75.3	51.5	86	41	1.43	−.65	
Qu'Appelle, Saskatchewan	2,115	27.68	29.92	−.02	64.6	+2.8	79.8	49.5	95	35	1.19	−.74	
Moose Jaw, Saskatchewan	1,759				67.7	+4.4	82.7	52.7	99	38	.36	−1.32	
Swift Current, Saskatchewan	2,392	27.16	29.93	+.01	64.1	+.8	78.8	49.4	93	39	.29	−1.55	
Medicine Hat, Alberta	2,365	27.49	29.94	+.04	67.2	+.5	83.9	50.5	97	38	.43	−.99	
Calgary, Alberta	3,540	26.38	30.00	+.06	61.1	+2.4	77.6	44.6	91	32	.51	−1.82	
Banff, Alberta	4,521				57.6	+3.8	74.7	40.4	85	30	.44	−1.87	
Prince Albert, Saskatchewan	1,450	28.37	29.90	−.03	64.2	+4.1	76.8	51.5	94	41	.62	−1.62	
Battleford, Saskatchewan	1,592	28.21	29.92	−.01	65.4	+4.9	81.3	49.4	100	36	.75	−1.15	
Edmonton, Alberta	2,150	27.61	29.93		61.1	+1.7	76.6	45.6	90	36	.03	−2.37	
Kamloops, British Columbia	1,262												
Victoria, British Columbia	230	29.79	30.04	+.02	62.2	+2.3	71.3	53.0	87	50	.31	−.30	
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170												
St. George's, Bermuda	158												
LATE REPORTS FOR JULY 1939													
Quebec, Quebec	296	29.58	29.90	0.00	68.8	+2.1	77.0	60.6	90	51	4.26	+0.06	
Kamloops, British Columbia	1,262	28.63	29.95	+.01	70.6	+.8	84.7	56.4	107	48	.67	−.35	
Estevan Point, British Columbia	20	30.00	30.03	−.05	56.2	+.8	61.1	51.2	72	42	4.96	+2.04	

TABLE 4.—*Severe local storms, August 1939*

[Compiled by Mary O. Souder from reports submitted by Weather Bureau officials]

[The table herewith contains such data as has been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the United States Meteorological Yearbook]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Luverne, Minn., and vicinity	1	P. m.			$10,500	Rain and flood	240 feet of railroad track washed out; highways to south and west inundated in places; $10,000 property damage; $500 loss to crops.
Pratt and Cunningham, Kans.	1				3,000	Tornadic winds	Damage to farm buildings; telephone and power lines down.
Gillespie, Ill., vicinity of	2	3:30 p. m.	250		2,500	do	Property damage, $2,000; loss to crops, $500. Greatest destruction over a strip 690 yards long; entire path 7 miles long.
Pratt County, Kans.	2	P. m.		0		Tornado	Buildings on one farm badly damaged. Twice before during the past year the buildings on this farm have been destroyed by tornadoes. Damage not estimated.
Lebanon, Tenn.	2-3	do			100,000	Rainfall	Water 3 to 4 feet deep flooded stores and downtown areas; 2 railroad bridges washed out; light and power service interrupted; much loss to crops and damage to farmlands.
Lake Worth, Fla., south of	4			0		Tornado	Little damage reported.
Pima and Cochise Counties, Ariz.	5				1,550	Heavy rains	Railroad bridges and grades damaged.
Franklin, Ill.	6				50,000	Heavy hail	Loss to crops.
Murrayville, Ill.	6				1,000	Wind	Property damaged.
Sabetha, Kans., and vicinity	7	2 p. m.	[1] 3½		5,000	do	Loss to crops, $2,500; damage to farm buildings, power, and telephone lines, $2,500; path 10 miles long.
Roy, N. Mex.	7	2:30 p. m.	[1] 3		10,000	Heavy hail	Chief loss to crops.
Garfield, Kans., vicinity of	7	3:30 p. m.		0		Tornado	Buildings on one farm damaged.
Clinton County, Iowa	7			1	100,000	Heavy rain	In the open country roads were badly damaged by the downpour, small streams overflowed their banks flooding lowlands and washing out many culverts and several bridges. A truck plunged into a swollen creek about three-fourths of a mile north of Elvira at the approach to a bridge washout and a boy, age 7, was swept away by the floodwaters and drowned. Sewers damaged, basements flooded, streets covered with mud and debris; sidewalks undermined.

[1] Miles instead of yards.

TABLE 4.—*Severe local storms, August 1939*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Pleasant Plains, Ill.	7				$3,000	Electrical	Residence and barn damaged.
Kalamazoo County, Mich.	8	2:45–3:15 p. m.	83–167	2	1,050,000	Tornado	The tornado made its first dip in Pretty Lake, having started just southwest of it, producing a waterspout witnessed by several persons. The cloud roared above the trees as it passed northeastward. It dipped again in the vicinity of Texas Corners damaging buildings, trees, and poles. In southern Kalamazoo damage to industrial buildings was $150,000. In the southern portion of Comstock 25 homes, many garages, buildings, and hundreds of trees were demolished. 6 large pine trees in one farm yard lifted out of the ground, carried to the height of 100 feet and dropped in the yard and adjoining fields. 75 persons injured; property damage, $1,000,000; loss to crops, $50,000; path 20 miles long.
Kent County, Mich.	8	3 p. m.	50–100	0	550,000	do	This storm did not strike a thickly settled area. 10 persons were injured; $500,000 property damage; loss to crops, $50,000; path 25 miles long.
Isabella County, Mich.	8	4:30 p. m.	100–167	0	90,000	do	Property damage, $80,000; crop loss, $10,000.
Lake Pleasant, Mich.	8			0	35,000	do	Funnel-cloud dipped into the lake 3 times, each time water, mud, and weeds were churned into the air to a height of about 50 feet. Damage to cottages and resort buildings; 2 persons injured.
Swan Creek and Freeland, Mich., and vicinity.	8				10,000	Wind	Property damage, $10,000; considerable crop loss not estimated.
Pajarito Plateau to Frijoles Canyon, N. Mex.	9	12:30–1 p. m.	[1] 2		500	Heavy hail	Property damaged.
Vester, Tenn., vicinity of	9	2:30 p. m.		0		Tornado	Residents reported that 7 inches of rain fell in a belt about ½ mile wide; cedar trees broken off 3 feet above the ground; number of barns and houses twisted or unroofed; church demolished, the roof of the structure falling almost vertically to the ground; path narrow and short.
Montgomery County, Iowa	10	3 p. m.			10,500	Heavy hail	Crop loss, $10,000; property damage, $500.
Shelby County, Iowa	10	3 p. m.	100–333	0	14,300	Tornado	Buildings on 5 farms damaged; loss to crops; livestock killed; 1 person injured; path 5 miles long.
Des Moines, Iowa, and vicinity.	10	4:55 p. m.			55,000	Rain	Over 2 inches of rain fell in about 80 minutes; traffic interrupted; 6,000 automobiles stalled; number of stores flooded; damage to streets, sewers, and sidewalks.
Clarke and Warren Counties, Iowa.	10	5–5:40 p. m.		0	132,500	Tornado and rain	Storm originated southwest of Osceola, Clarke County and traveled northeastward to near Milo in Warren County. Man injured when his barn was wrecked. Damage in Clarke County, $30,500. The storm lifted as it passed over the northern part of Clarke County lowering again as it reached the Warren County border. Buildings were demolished on at least 10 farms in Warren County and corn was flattened in an area about 1 mile wide and 15 miles long. On a farm equipped for livestock feeding, 18 of 22 buildings were damaged or wrecked with $102,000 damage. Terrific downpours of rain added to the storm damage by washing out roads, covering low fields, and breaking down corn.
Seneca and Sabetha, Kans., and vicinities.	10	6 p. m.				Wind	Trees broken; small buildings damaged; corn lodged; 2 threshing machine separators blown over and damaged.
Bern, Kans., vicinity of	10	P. m.				do	Number of trees uprooted; barn destroyed.
Spartanburg and Cherokee Counties, S. C.	10	do			1,000	Thunderstorm	Property damaged.
Michigan, western and central portions.	10			3	1,000,000	Tornadic winds	Scores of persons injured; damage to buildings; loss to crops. The Red Cross mobilized forces to dispense food and medical aid.
Minneapolis and St. Paul, Minn., and vicinity.	10				5,000	Thundersquall	Property damaged; trees uprooted; wires down; path about 25 miles long.
Kearney, Nebr., vicinity of	11	7–7:10 p. m.	[1] 1–4		100,000	Heavy hail	Much damage to roofs, windows, and greenhouses; small crop loss.
Collinsville, Ill.	11				2,500	Wind	Property damage.
Florida, southern and extreme northwestern portions.	11–12			1	2,000	Tropical disturbance	Property damage greatest and crop loss worst in the northwestern section. Several small boats sunk at Apalachicola and a warehouse at Port St. Joe damaged to the extent of $2,000. Man drowned at Cedar Key when rowboat capsized.
Buffalo and western New York	12–13			1	35,000	Thunderstorms	Lightning caused $10,000 damage in Buffalo and vicinity. In western New York damage of $25,000 occurred. 1 person drowned near Dunkirk when a boat overturned in a squall.
Mescalero, N. Mex.	13	2–3:40 p. m.	[1] 2½		1,000	Heavy hail and rain	$500 loss to crops; $500 property damage.
Buckeye, Ariz., vicinity of	13			1	85,000	Wind, rain, and hail	1,200 acres of cotton destroyed; buildings wrecked; 2 persons injured.
Lynchburg, Va.	14	1 p. m.			3,900	Thunderstorm	Barn and silo struck by lightning.
Sabetha, Kans.	14	P. m.				Wind	Trees uprooted; telephone and light wires blown down; damage not estimated.
Selma, Ala.,[2] and vicinity	14–15					Torrential rain and wind.	The Red Cross sent boats to Bogue Chitto Creek, 10 miles south of Selma, to rescue marooned cattle. 9 inches of rain recorded in 48 hours. Power service disrupted. U. S. highway 80 closed to traffic between Uniontown and Mobile. Much crop loss and property damage.
Hinton, Okla.	15	6:40 p. m.	[1] 14		15,000	Hail	Loss to cotton, late corn and gardens, $5,000; damage to property, $10,000; path 16 miles long.
Walston Springs, Tex.	16	3 p. m.				do	Loss to crops.
Wichita, Kans.	16	4–6 p. m.	[1] 10		28,000	Wind and rain	Damage to roofs, porches, and small buildings; interior of buildings damaged by rain; path 10 miles long.
Fountain Inn, S. C., and vicinity.	17	P. m.	20–50	0	5,000	Tornado	Farm residence and outbuildings demolished, a residence damaged; livestock killed; path 5 miles long. Greatest destruction over a path 20 yards wide.
Oconee, Anderson and Greenville Counties, S. C.	17–18				48,500	Heavy rain	Number of bridges over small streams damaged or washed with local damage to highways, $30,000; loss to crops, $18,500.
McCullers, N. C.	18	Noon	200	1		Tornado and rain	Small tenant house and number of outbuildings destroyed; chickens killed; trees uprooted; much loss to crops; 2 persons injured; path 440 yards long.
Malaga, N. Mex.	18	3–4 p. m.	[1] 1		25,000	Heavy hail	Loss to crops.
Callahan, Fla.	18			0		Tornado	Little damage reported.
Baltimore, Md., and vicinity	18–19	5:29–6:15 a. m.				Tornadic wind and rain.	6 houses unroofed; 2 boats disabled in the bay; other property damaged.
Fleeton, Va., to Leonardtown, Md.	19	12:15 a. m.		1	100,000	Tornado	8 persons injured; property damaged.
Des Moines, N. Mex.	19	Midnight			1,000	Heavy hail	Loss to crops.
Bassetts, Va., vicinity of	19				12,000	Flood	Damage to roads and bridges.
Cayuga, N. Y.	20					Wind and hail	Barn wrecked; many trees blown over; much loss to crops.
Cold Springs, Okla.	22	8–9 p. m.	[1] 1		600	Wind	Property damaged; path 3 miles long.
Eureka, Kans., vicinity of	24	3:10 a. m.	880		1,000	Heavy hail	Crops damaged; leaves stripped from corn; telephone and power service interrupted; path 6 miles long.

[1] Miles instead of yards.
[2] From press reports.

TABLE 4.—*Severe local storms, August 1939*—Continued

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks
Cowley County, Kans.	24	4:15 p. m.	[1] 1		$10,000	Tornadic winds	Chief damage to buildings; path 10 miles long.
Weir to Chetopa and vicinities.	24	7 p. m.	[1] 1–5		85,000	Wind and hail	Corn lodged; windows and trees broken; barns and silos destroyed; houses twisted on foundations; path 30 miles long.
Ponca City and Blackwell, Okla.	24	7 p. m.	[1] 7	1	25,000	Wind	Trees and power lines blown down; considerable damage to buildings; path 20 miles long.
Ottawa and Craig Counties, Okla.	24	7–9 p. m.		2	500,000	Wind, rain, and hail	More than 100 buildings completely or partially destroyed; many farm animals and fowls killed by hail or drowned. One area, east of Vinita, Craig County, about 5 miles wide and extending northward 20 miles to the Kansas line, completely denuded by hail. Many families made homeless; the American Red Cross established headquarters in the high school to provide food and sleeping accommodations.
Wagoner and Muskogee, Okla.	24	9:30 p. m.	[1] 10		20,000	Wind	This storm doubtless in connection with the one that occurred over the extreme northeastern portion of the State in Ottawa and Craig Counties a few hours earlier. Loss to crops, $10,000; property damage, $10,000.
Lincoln County, Mont.	25	3–4 p. m.	[1] 2		1,200	Wind and hail	Loss to crops, $500; property damage, $700.
Hamburg, Ill.	25				2,000	Hail	Loss to crops.
Mount Olive, Ill.	25				100,000	Heavy hail	Property damage, $85,000; loss to crops, $15,000.
Issaquena County, Miss.	30	P. m.	[1] 2½		60,000	Hail	Path 15 miles long; no details.
Sunflower County, Miss.	30	P. m.	[1] 2		40,000	do	Path 5 miles long; no details.
Washington County, Miss.	30	P. m.			10,000	Thundersquall and hail.	No details.
Montgomery County, Tenn.	30				50,000	Heavy hail	Much corn damaged; loss in tobacco, $50,000.
St. Joseph, La., vicinity of.	31	12:30 a. m.	[1] 2		3,000	Straight-line wind	Loss to crops, $2,500; property damage, $500.
Dumas, Ark.	31				500	Wind	Property damaged.

[1] Miles instead of yards.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, August 1939

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, August 1939

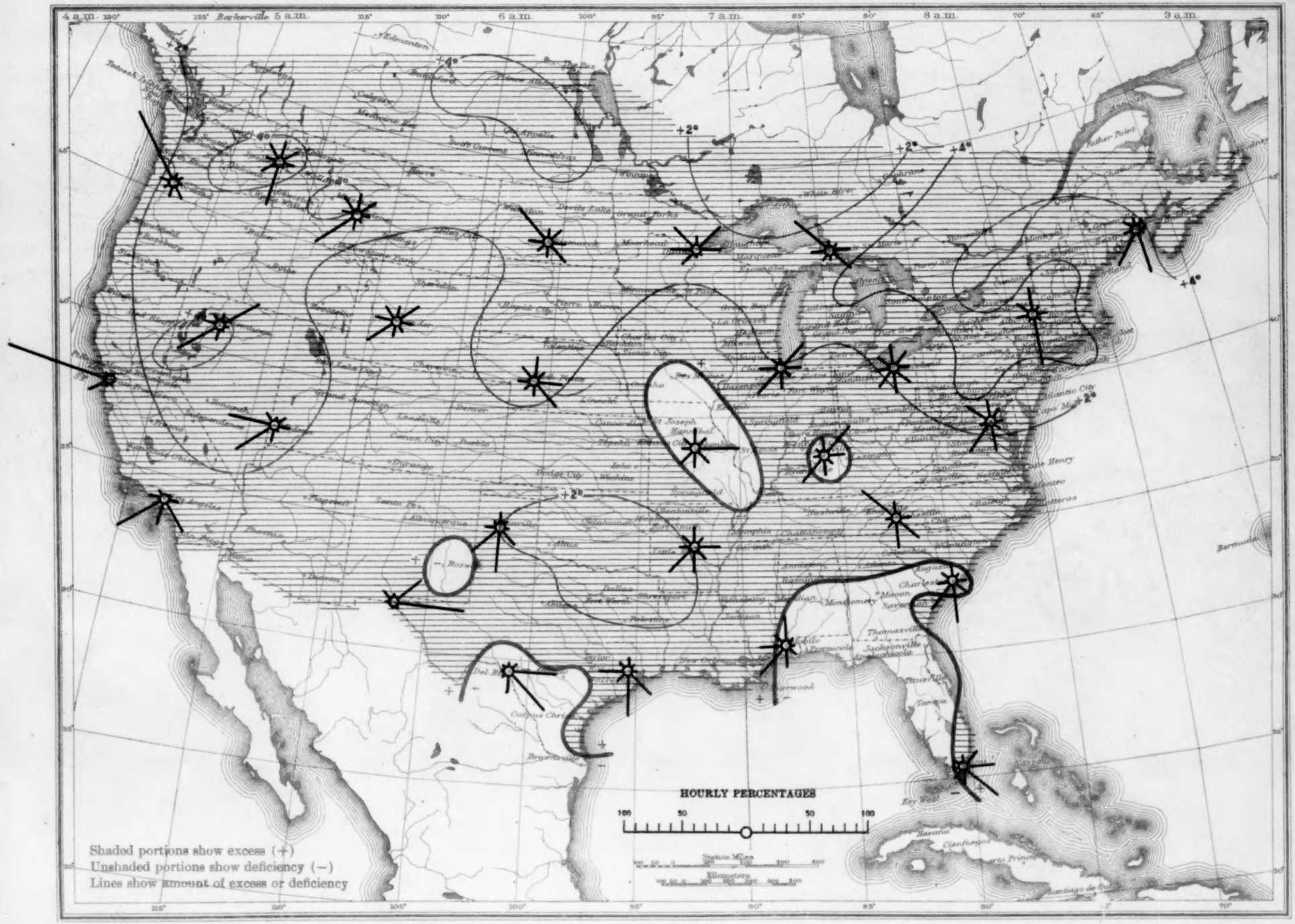
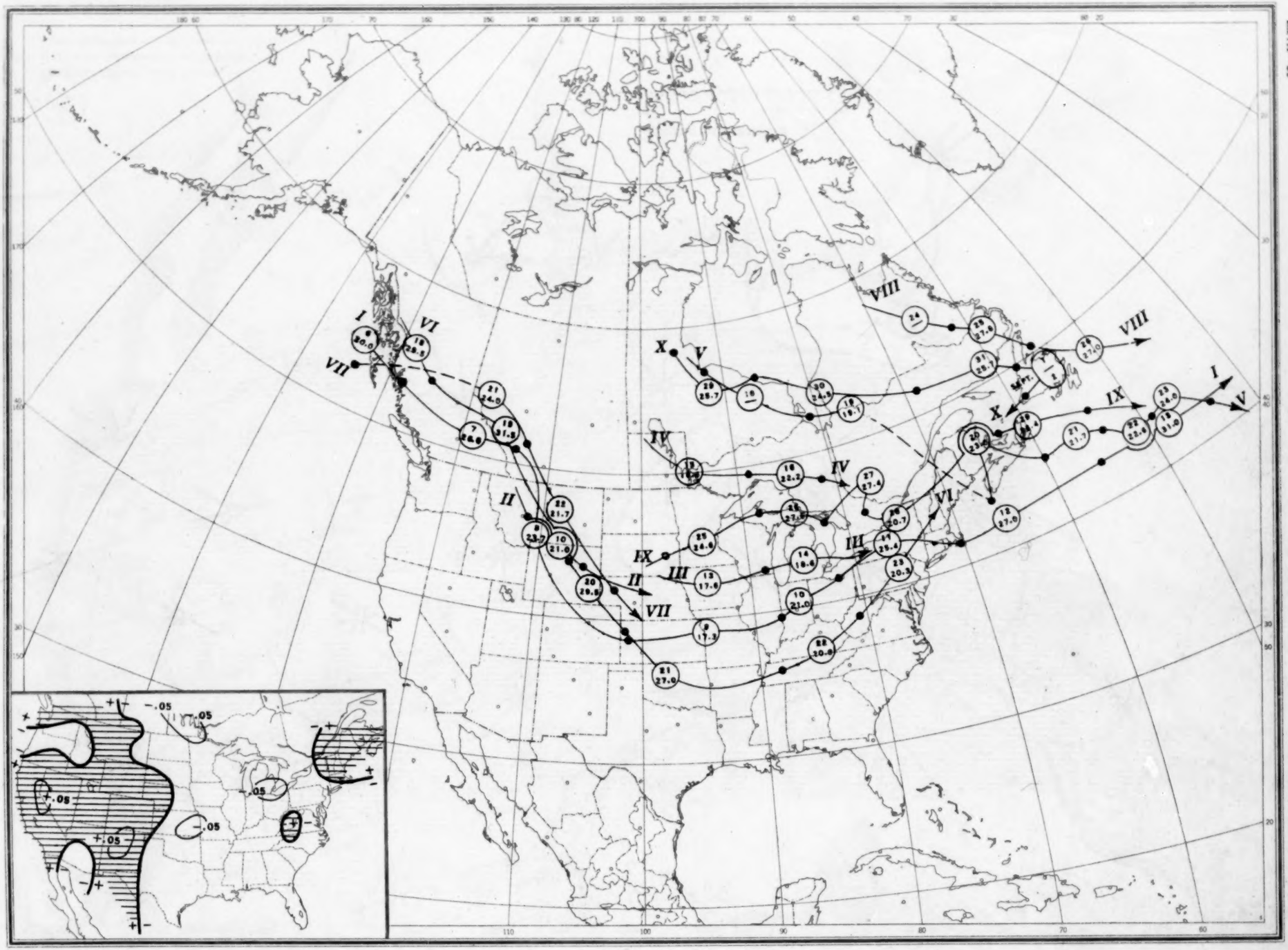


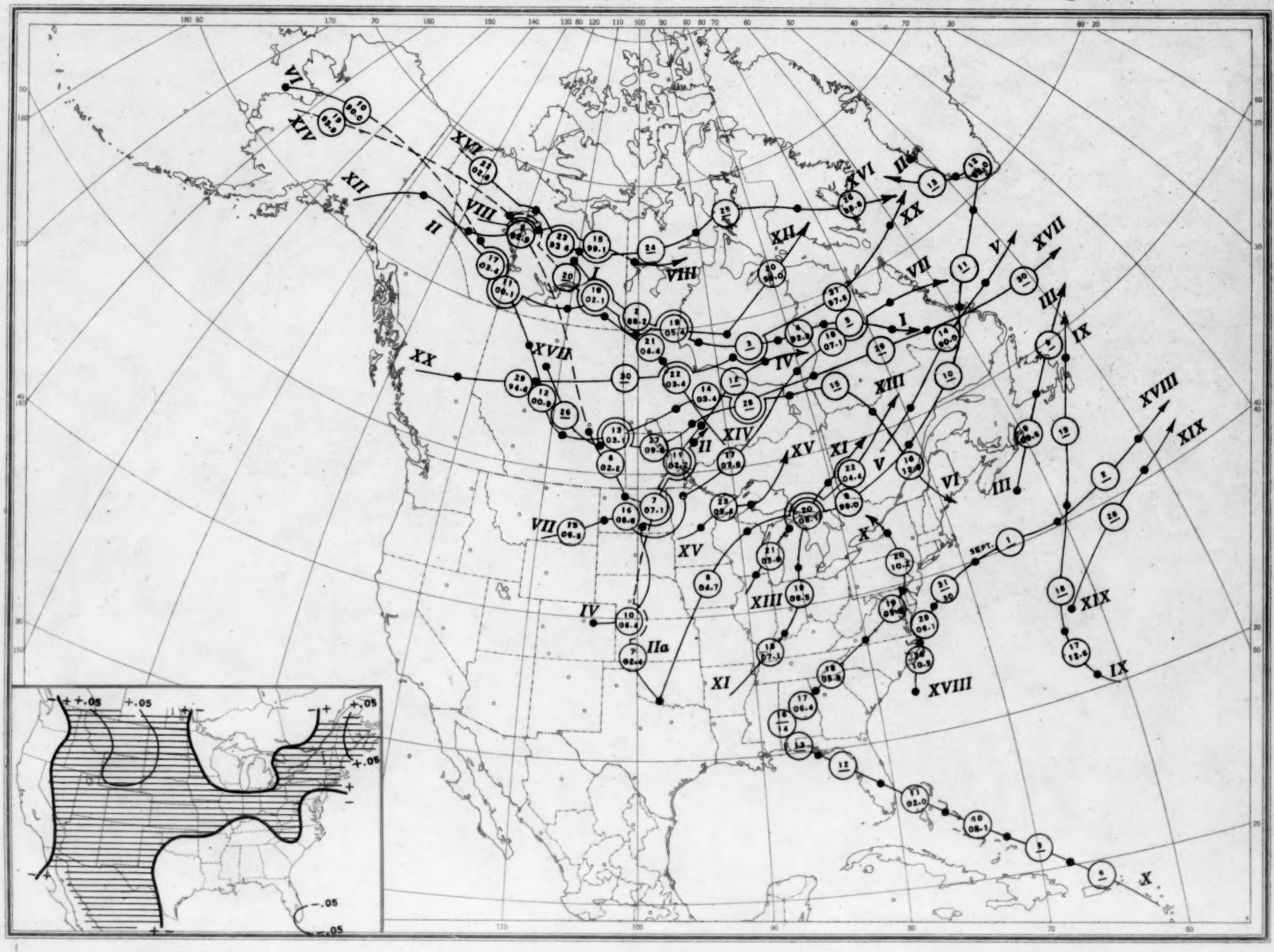
Chart II. Tracks of Centers of Anticyclones, August 1939. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

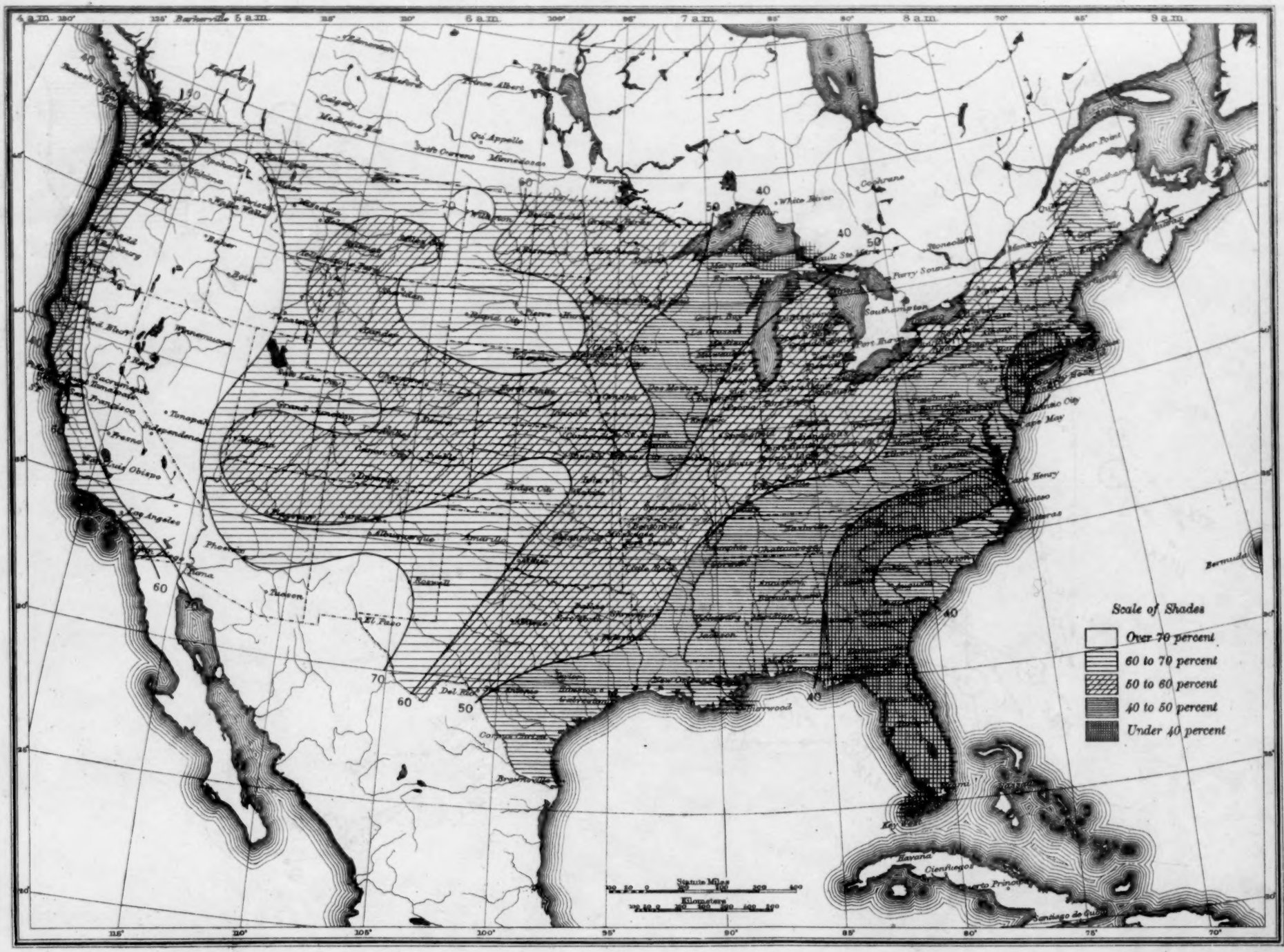
Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, August 1939. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, August 1939



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August 1939. M. W. R.

Chart V. Total Precipitation, Inches, August 1939. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, August 1939. (Inset) **Departure of Precipitation from Normal**

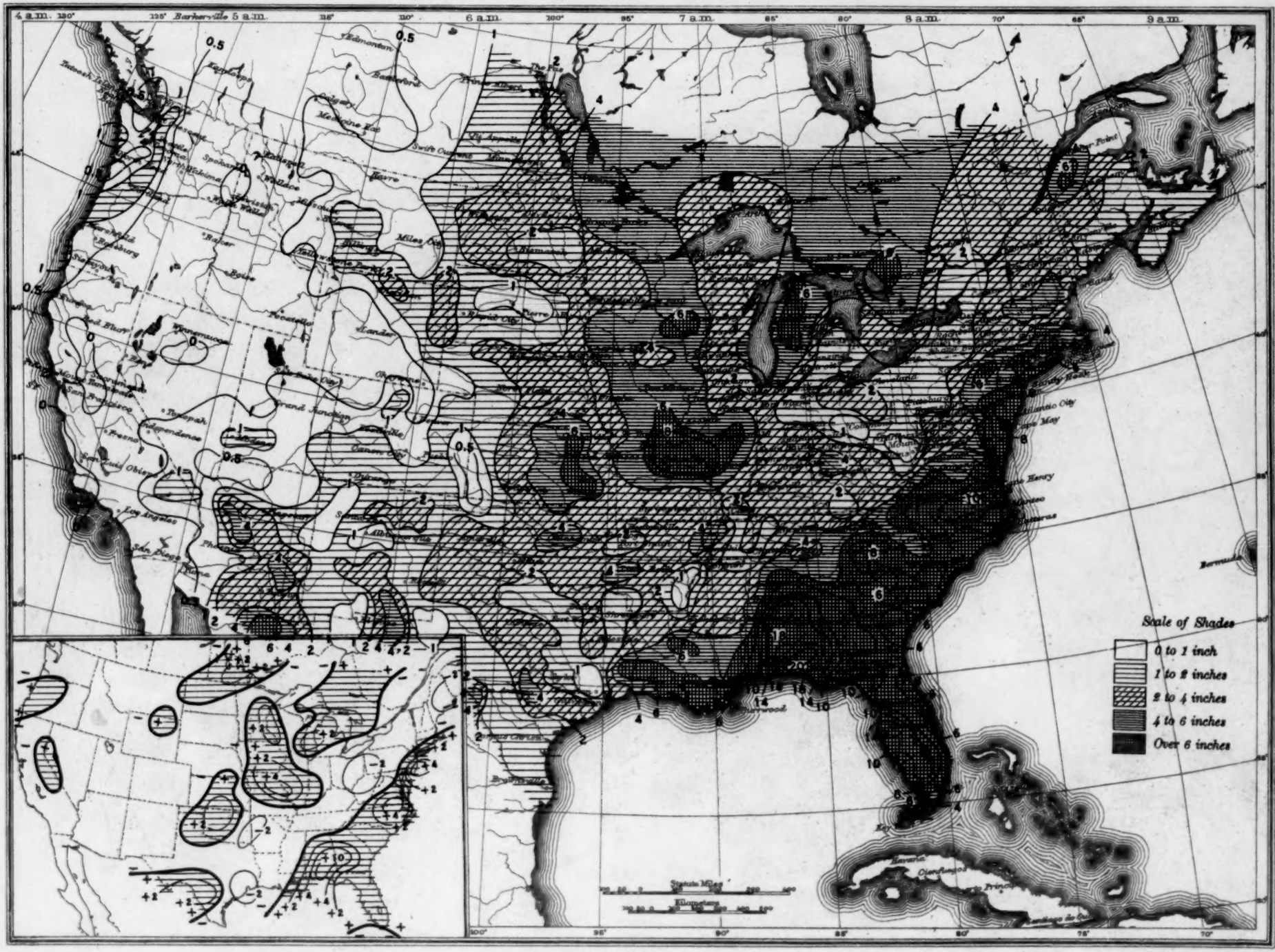

Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, August 1939

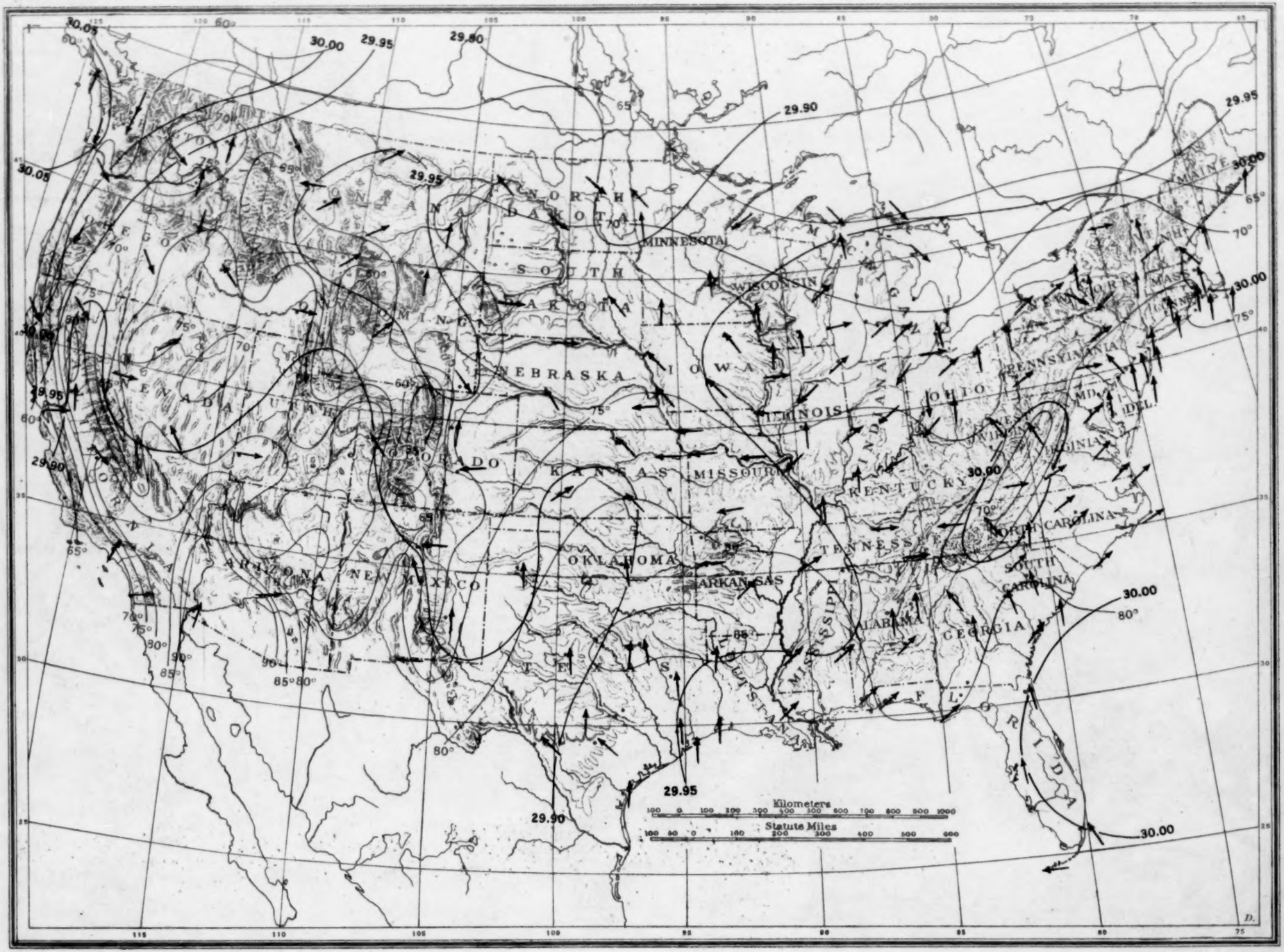

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) August 1939

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) August 1939

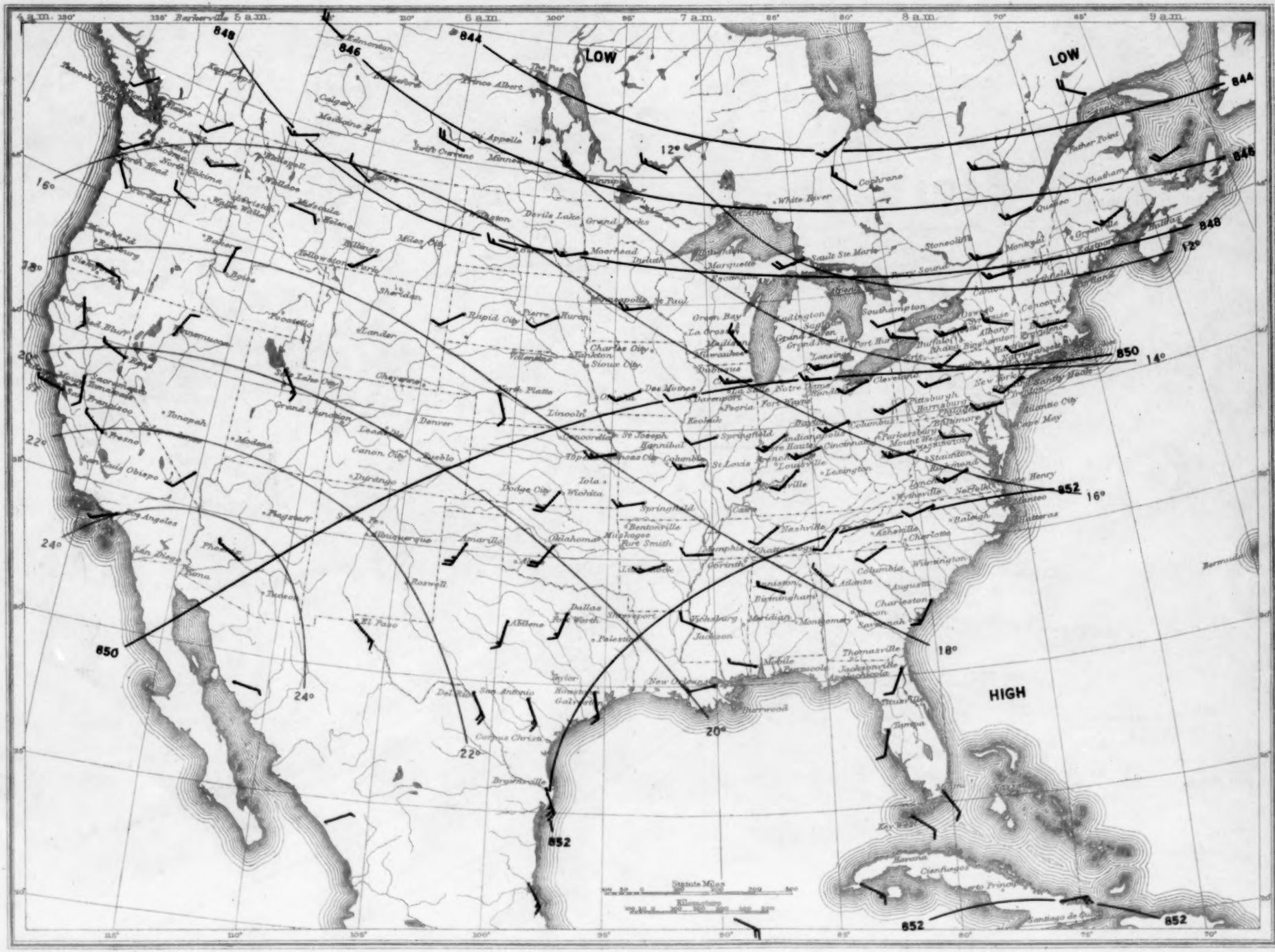

Chart IX. Isobars (mb) Isotherms (°C.) and Resultant Winds for 3,000 Meters (m. s. l.) August 1939

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August 1939. M. W. R.

Chart X. Isobars (mb) Isotherms (°C.) and Resultant Winds for 4,000 Meters (m. s. l.) August 1939

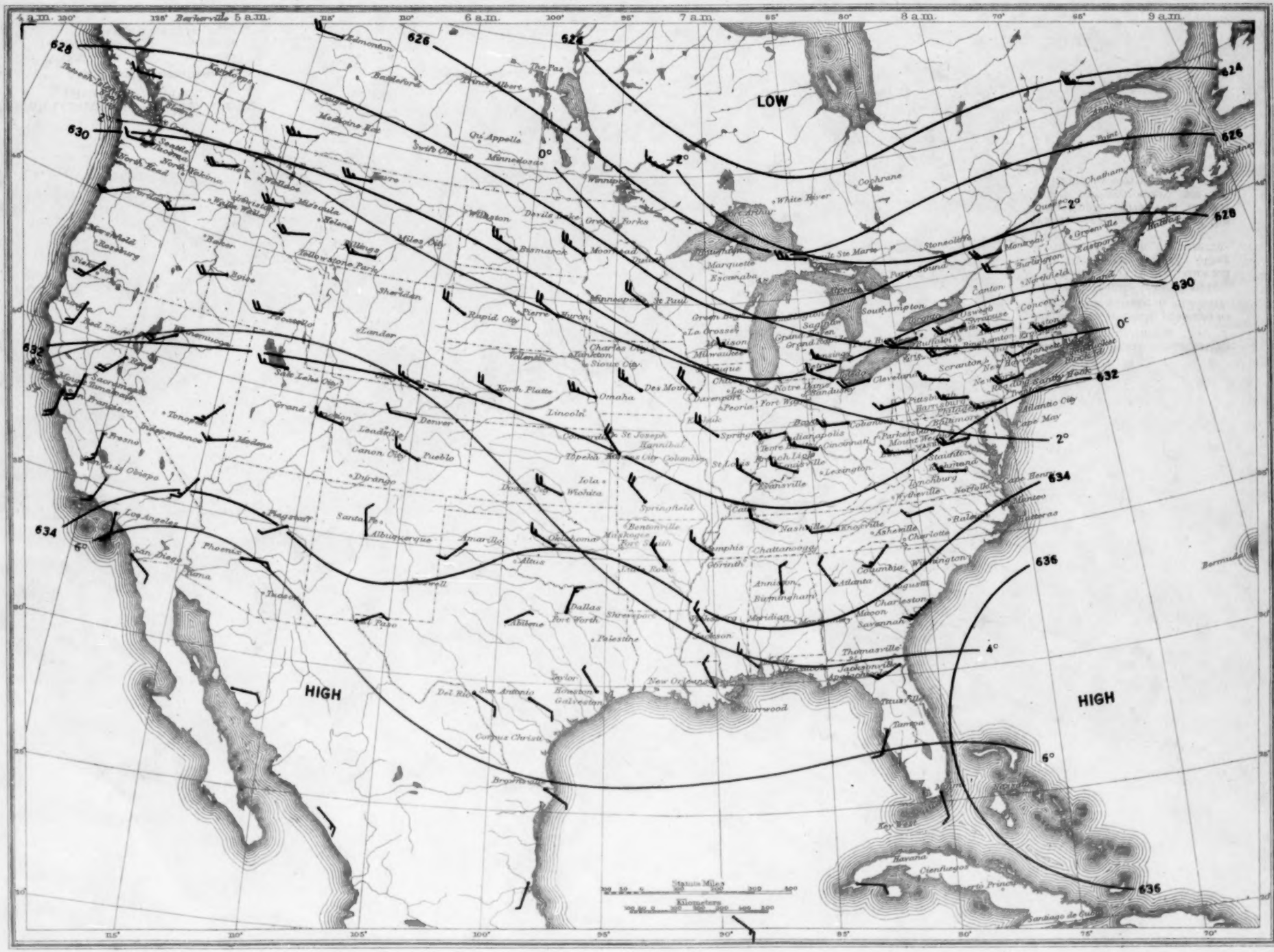

Chart XI. Isobars (mb) Isotherms (°C.) and Resultant Winds for 5,000 Meters (m. s. l.) August 1939

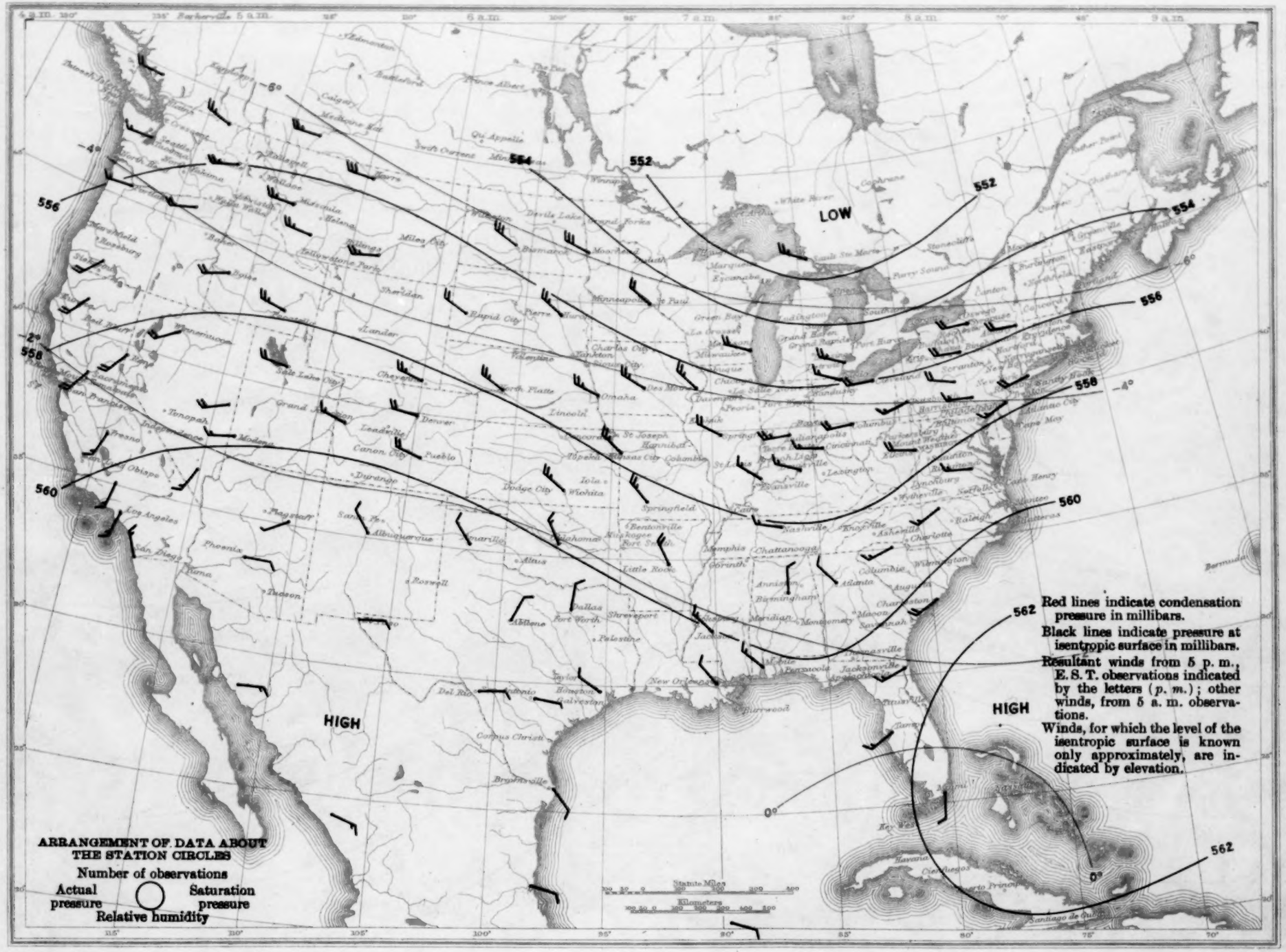

Chart XII. Mean Isentropic Chart, August 1939 (Potential Temperature 315° A.)

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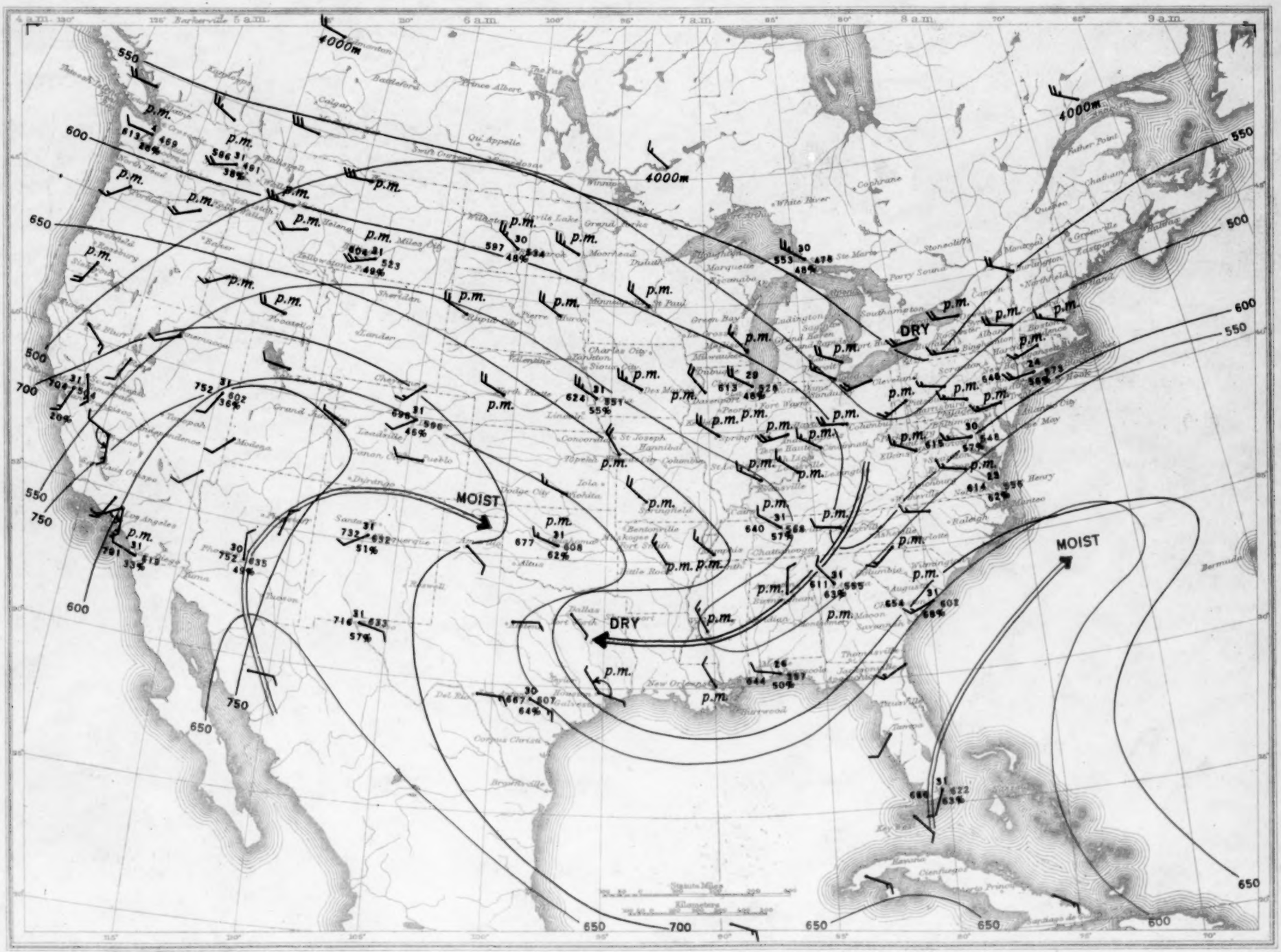

Chart XIII. Weather Map of North Atlantic Ocean, August 12, 1939

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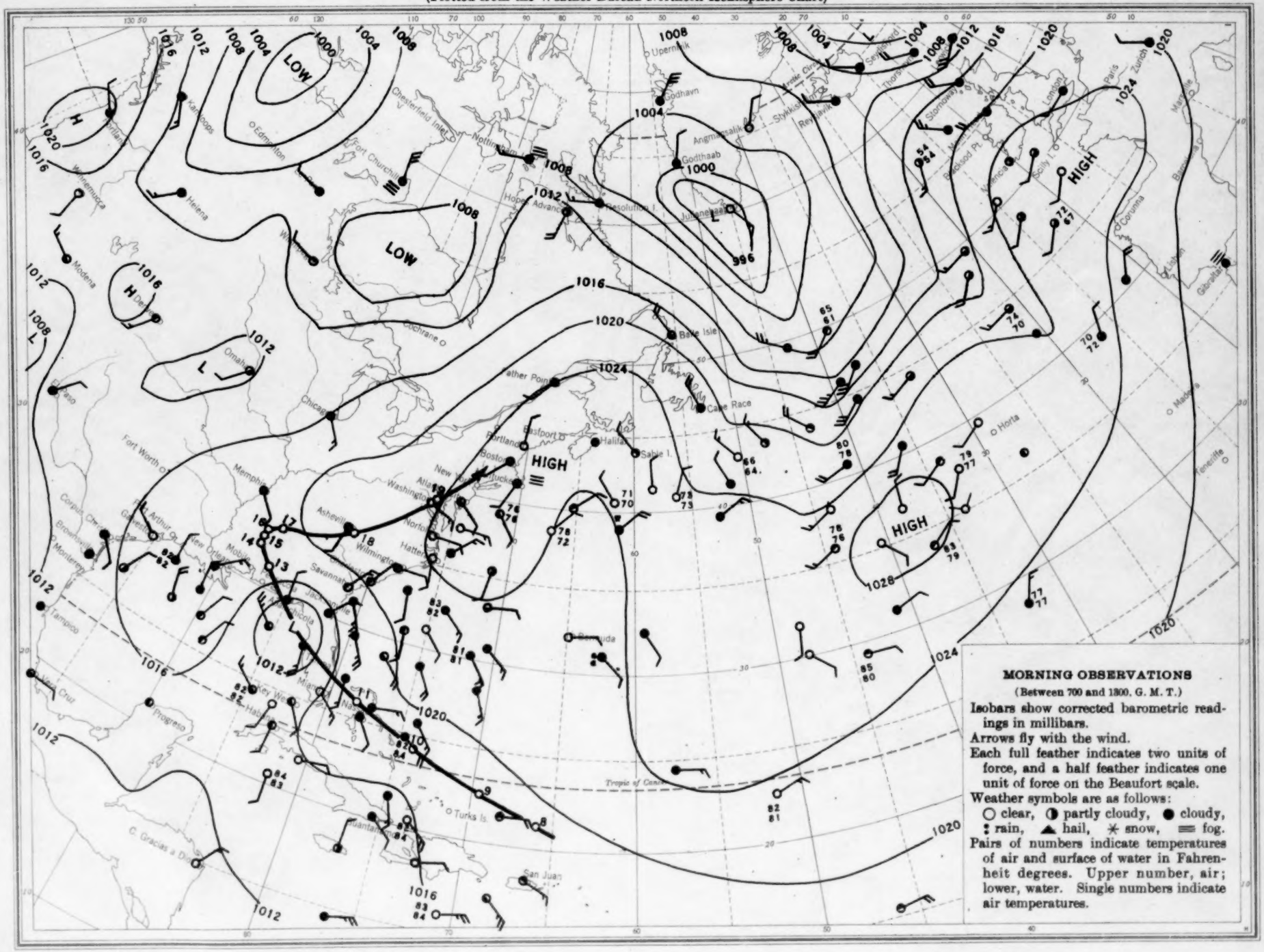
(Plotted from the Weather Bureau Northern Hemisphere Chart)



MORNING OBSERVATIONS

(Between 700 and 1300. G. M. T.)

Isobars show corrected barometric readings in millibars.

Arrows fly with the wind.

Each full feather indicates two units of force, and a half feather indicates one unit of force on the Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail, ✳ snow, ═ fog.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.